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BASELINE INVESTIGATION OF DEEPWATER DUMPSITE 106
(MAY 1974)

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

PREPARED FOR
ENVIRONMENTAL PROTECTION AGENCY

DECEMBER 1975

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NOAA Dumpsite Evaluation Report 75—1

May 1974
Baseline Investigation
of Deepwater
Dumpsite 106

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National Oceanic and Atmospheric Administration, and the
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December 1975

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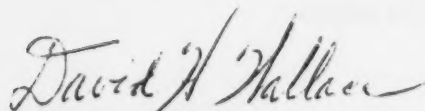
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Preface

The National Oceanic and Atmospheric Administration (NOAA) has basic responsibility to conduct programs of monitoring and research to determine the effects of ocean dumping. In May, 1974, NOAA conducted an environmental baseline investigation in the Deepwater Dumpsite (DWD-106) and its vicinity, located 90-miles east of Cape Henlopen, Delaware, in which large amounts of industrial wastes from the New York/New jersey metropolitan area are dumped. This document presents the reports by the individual principal investigators, including a summary chapter containing major findings.

A second description of seasonal baseline data was obtained by NOAA in July, 1975, using both surface ships and manned deep submersible capability. The results of the 1975 investigation are expected to be published in late 1976.

Establishment of appropriate descriptive baseline conditions is the first step in ascertaining the impact of dumping on ocean ecosystems.



David H. Wallace
Associate Administrator
for Marine Resources

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INTRODUCTION AND SUMMARY

Background

Public Law 92-532, the Marine Protection, Research, and Sanctuaries Act of 1972 put an end to the unregulated disposal of wastes in offshore waters of the United States, including the Great Lakes. This Act was the culmination of concern by the Administration, the Congress, scientists, and the public at large over the potential dangers to the environment and to public health of unrestricted ocean dumping. The National Oceanic and Atmospheric Administration (NOAA) has the responsibility under Title II of the Act to conduct monitoring and research to determine the environmental effects of the dumping of waste materials into ocean waters.

In 1974 NOAA initiated a planned series of three seasonal baseline investigations of Deepwater Dumpsite 106 (DWD 106) to assess the impact of present dumping activity and to provide a comparative base for future assessments. The series includes: spring - May 1974; summer - July 1975; and there are tentative plans to conduct a winter baseline survey in early 1976.

The dumpsite is located 106 nautical miles (nmi) southeast of Ambrose Light and 90 nmi due east of Cape Henlopen, Delaware. The site is used by more than 25 different dumpers in the New York-New Jersey area to dispose of acid waste and industrial chemicals. In 1974, a total of 100 million gallons of liquid wastes were dumped at the site. Wastes are dumped just beneath the sea surface by barge moving at a speed of 3 to 5 knots. Typical waste materials include: inert ore slurry from production of titanium dioxide pigments, residual sludge from galvanizing and plating operations, liquid wastes from production of textile manufacturing and from etching and photographic processes, water solutions of inorganic salts, and similar materials derived from diverse manufacturing processes.

The dumpsite is bounded by 38°40'N, 39°00'N, 72°00'W, and 72°30'W and is over the continental slope and rise. Depths range from 1550 m in the northwest corner of the quadrangle, where relief is rugged and the slope dissected by small canyons, to 2750 m in the southeast corner. Any of several water masses can occupy different levels in the water column at a given time. Gross circulation patterns are affected by mixing across frontal zones. Along the coast, currents flow predominantly southward, and seaward the Gulf Stream flows generally northeastward. The slope of water appears to circulate in a cyclonic gyre.

Conceptual Approach

In this instance we are dealing with the ocean disposal of a fairly large mass of matter, either in solution, or in suspension. Dispersion characteristics are determined by gravity, the action of currents, movement of sediment on the bottom, and other phenomena, such as density and thermal barriers.

The approach employed by NOAA to determine the effects of ocean dumping calls for a baseline to be established--a description of the biological, geological, chemical, physical oceanographic, and climatic conditions of the

area, against which future changes can be assessed, and for selected research studies to be performed. In this way, it is believed that:

- Living and other natural resources of an area that could be jeopardized by dumping, particularly fisheries, plankton, benthos, and related components of the ecosystem, can be identified.
- Information needed to predict the effects of natural events and man-induced changes in the ocean ecosystem, can be provided, and
- The strategy for monitoring critical indicators of environmental conditions can be developed.

An important objective in establishment of a baseline is statistical definition of the natural variation, both spatial and temporal, against which monitoring can then determine deviations or trends from a norm. The establishment of baselines includes such time-series data as are necessary to adequately measure natural variability. Sampling requirements for determination of statistically valid baselines will vary widely according to the parameter concerned, as will requirements in detecting deviations for purposes of evaluating environmental impact.

In the DWD-106 area, there are large natural fluctuations in ocean systems, both spatially and temporally. These variations were considered in the statistical design of the May 1974 investigation, and concentration of effort was placed on the more important parameters while still keeping the approach broad enough so the data could be considered an adequate baseline.

Operational Activities

The NOAA ships Delaware II and Albatross IV conducted field surveys during the period May 9-24, 1974. Specific objectives were to obtain baseline environmental data for the spring season, including:

- Distribution and abundance of benthic biota (fish, shellfish, epifauna).
- Distribution of selected contaminant materials in the benthic environment.
- Water column characteristics.
- Geological characteristics of the sea floor.

The May 1974 survey date was chosen as being representative of spring conditions--the period before thermal stratification occurs. Plans for field operations included use of a submersible for in situ observations, but this phase of the survey was cancelled because of operational circumstances.

Principal investigators for the May 1974 field operations were:

Program Coordinator

J. F. Hebard, NOAA

Chief Scientist	R. Dill, NOAA
Party Chief, <u>Delaware II</u>	J. Pearce, NOAA
Party Chief, <u>Albatross IV</u>	M. Ingham, NOAA

Special Studies:

Geology	B. Heezen, Lamont-Doherty Geological Observatory
Water Mass Properties	C. Warsh, NOAA
Zooplankton	H. Austin, New York Ocean Sciences Laboratory, MARMAP Group, NOAA
Carnivorous Nekton	W. Krueger, University of Rhode Island
Benthic Megafauna	R. Menzies, A. Paul, Florida State University
Chemistry of Pollutants	J. Pearce, NOAA
Radioactive Analysis	R. Dyer, EPA

Reports by principal investigators appear in this volume in the following order:

1. NOAA ship Albatross IV cruise 74-5 report of May 9-24, 1974, survey of Deepwater Dumpsite 106, by Merton C. Ingham, NOAA National Marine Fisheries Service, Atlantic Environmental Group, Narragansett, R.I. 02882.
2. NOAA ship Delaware II cruise 74-2 report of May 13-21, 1974, survey of Deepwater Dumpsite 106, by James P. Thomas and John P. Pearce, NOAA National Marine Fisheries Service, Sandy Hook Laboratory, Highlands, N.J. 07732 and by John A. Musick, Virginia Institute of Marine Science, Gloucester Point, Va. 23062.
3. Investigation of radioactive waste disposal at Deepwater Dumpsite 106--sampling program May 1974, by Robert Dyer, Oceanographer, Office of Radiation Programs, Environmental Protection Agency, Washington, D.C. 20460.
4. Photographic reconnaissance of continental slope and upper continental rise, by Bruce C. Heezen, Columbia University Department of Geological Sciences and Lamont-Doherty Geological Observatory, Palisades, N.Y. 10964.
5. Physical oceanography historical data for Deepwater Dumpsite 106, by Catherine E. Warsh, NOAA National Marine Fisheries Service, Atlantic Environmental Group, Narragansett, R.I. 02882.

Present address: Oceanographic Division, Office of Marine Surveys and Maps, National Ocean Survey, NOAA, Rockville, Md. 20852.

6. Physical oceanographic observations at Deepwater Dumpsite 106 -- May 1974, by Catherine E. Warsh, NOAA National Marine Fisheries Service, Atlantic Environmental Group, Narragansett, R.I. 02882.
7. Micronutrient analysis of seawater samples taken at Deepwater Dumpsite 106 May 1974, by Harold Petersen, NOAA National Marine Fisheries Service, MARMAP Field Group, Narragansett, R.I. 02882.
8. Analytical results for water-column samples collected at Deepwater Dumpsite 106--May 1974, by Francis T. Brezenski, Technical Support Group, Environmental Protection Agency, Region II, Edison, N.J. 08817.
9. Preliminary investigation of benthic resources at Deepwater Dumpsite 106, by John B. Pearce and James Thomas (Sandy Hook, N.J., Laboratory) and Richard Grieg (Milford, Conn., Laboratory), NOAA National Marine Fisheries Service, Middle Atlantic Coastal Fisheries Center, Highlands, N.J. 07732.
10. Archibenthic and abyssobenthic fishes of Deepwater Dumpsite 106 and the adjacent area, by J. A. Musick, C. A. Wenner, and G. R. Sedberry, Virginia Institute of Marine Science, Gloucester Point, Va. 23062.
11. An analysis of plankton from Deepwater Dumpsite 106, by Herbert M. Austin, Research Scientist, Fisheries Oceanography Department, New York Ocean Science Laboratory, Montauk, Long Island, N.Y.
Present address: Oceanographic Services Office, EM3, Office of Environmental Monitoring and Prediction, NOAA Rockville, Md. 20852.
12. Systematic analysis of midwater fishes at Deepwater Dumpsite 106, by William Krueger, Michael J. Keene, and Aimee A. Keller, Department of Zoology, University of Rhode Island, Kingston, R.I. 02981.

Copies of R. Menzies and A. Paul benthic megafauna study Historical Data Base of the Mid-Atlantic Bight and Appendix A--Combined Bibliography of Sources of Data Relevant to Deepwater Dumpsite Activities (a compiled bibliography and listing of species names in the trawl bank of Site-A and Site-E) are at NOAA Environmental Data Service's National Oceanographic Data Center, Washington, DC 20235 Appendix B--Epifaunal Photo Data Bank at Deepwater Dumpsites (180 enlargements of laboratory-preserved specimens taken at sites by trawling) is held by Robert J. Menzies, Department of Oceanography, Florida State University, Tallahassee, FL 32306.

Major Findings

Although the primary objective of the May 1974 baseline was to obtain a description of environmental conditions at DWD-106 and in its vicinity, certain findings relative to the overall effects of ocean dumping may be significant. However, caution should be exercised in extrapolating conclusions from the findings at this stage of the study, and until the summer (July 1975) and winter (February 1976) baseline data can be studied. A summary of May 1974 survey findings follows.

Physical Oceanography

A. Temperature inversions were common in the upper 200 m throughout the area. The dumpsite, because of its location, appears to be subject to the presence of temperature inversions caused by the interaction of the relatively cool, less saline shelf water and the warmer, more saline Gulf Stream water--and by the occasional southwestward movement of eddies through the region on the landward side of the Gulf Stream. Freshwater runoff, and predominantly northwesterly to westerly winds, enhance the outflow of shelf water over slope water.

B. Water masses are best identified by their temperature-salinity relationship, owing to the seasonal variation of shelf/slope waters.

C. The shelf/slope front in May 1974 was located over the shelf break. A warm water eddy was observed between 50 and 350 m in the northeast part of the area. Below 350 m North Atlantic Central Water was present, and at 1500 to 2700 m (very near the bottom) North Atlantic Deep Water was present.

Geology

A. Erosion is occurring in the transition zone between the base of the continental slope and the upper continental rise, on portions of the upper and lower continental rise, and in submarine canyons that are incised in the slope near the dumpsite.

B. The upper continental rise and areas between canyons have a uniform sediment cover and negligible current activity.

Metal Concentrations

A. Metal concentrations in sediment samples from the continental shelf were significantly less than in samples from deeper areas.

B. Metal concentrations were higher in and near the Hudson Canyon. This can indicate a possible inshore source of metals, and their transport seaward through the canyon--as opposed to their presence through direct ocean waste disposal.

C. Most heavy metals in the finfish and invertebrates sampled showed little variation, with lead showing greater variation than other metals. One species, Alepacephalus agassize, had the highest concentration of heavy metals. Concentrations in the other species sampled were consistent with values noted in previous studies in the area.

Fishes

- A. Diversity of benthic species was greater and less variable on the slope than on the shelf. The biomass of demersal species increased at the shelf break and remained constant to 2000 m where it decreased. Numerical abundance of individuals caught showed an expected decrease with depth.
- B. Crustaceans appear to be the dominant food item for demersal species in the area, based upon fragments found in fish stomachs. Amphipods and isopods were the other principal foods.
- C. Thirty-three species of midwater fishes were identified as possible spawners in the vicinity of the dumpsite. Four species were identified as eel leptocephali and 29 as mesopelagic species, chiefly gonostomatids and myctophids.

Plankton

- A. Diversity of identifiable shelf species of plankton was found to be greatest at stations near the Hudson Canyon.
- B. Juvenile fish and fish larvae of tropical origin were found in surface waters, but the highest standing crop was dominated by shelf spawning species.
- C. Copepods were the dominant species of the invertebrate zooplankton collected. Both boreal and subtropical species were found; boreal species were predominate in shelf and slope waters.

NOAA SHIP ALBATROSS IV CRUISE 74-5 REPORT OF MAY 9-24, 1974
SURVEY OF DEEPWATER DUMPSITE 106

Merton C. Ingham

NOAA National Marine Fisheries Service
Atlantic Environmental Group
Narragansett, R. I.

INTRODUCTION

Cruise 74-5 by NOAA ship Albatross IV, and cruise 74-2 by NOAA ship Delaware II, were part of a joint effort during the May 1974 field investigation of Deepwater Dumpsite 106. This report describes the sampling operations of the Albatross IV during the period May 9 through 24, 1974, in and near Deepwater Dumpsite 106 (fig. 1).

CRUISE OBJECTIVES AND PERSONNEL

Objectives of the cruise were to study the chemical, biological, geological, and physical characteristics of Deepwater Dumpsite 106, particularly during the spring season. Scientific personnel included:

M. Ingham	NMFS/AEG (Field Party Chief)
S. Cook	NMFS/AEG
C. Warsh	ERL/MESA
I. Black	NMFS/MARMAP
M. Lewis	EDS/NODC
P. Twohig	NMFS/NEFC
S. Nicherson	NMFS/NEFC
C. Karnella	Smithsonian
J. Ruckavina	EPA
M. Simkovich	EPA
R. Smith	EPA
R. Pfann	Lamont-Dougherty

DESCRIPTION OF OPERATIONS

The cruise period was divided into two intervals. During the first interval, May 9-14, operations during the daylight hours were devoted to testing of an undulating oceanographic recorder (UOR) that had been acquired by NMFS. This work was conducted by a party of seven persons, on board for the first 5 days. They will report results of these tests in a separate report at a later date. Data for the characterization of the waters in the vicinity of



Figure 1.--Location of Deepwater
Dumpsite 106 -- delimited by
stations L,P,U,Z on figure 2.

DWD 106 were collected only at night during the first interval, except the night of May 9, which was spent steaming to the area of operations, and the night of May 14, which was spent steaming to Floyd Bennet Field to off-load the UOR test team. During the second interval, May 15-24, data were collected on stations in and near DWD 106 in a 24-hour-per-day operation. Table 1 gives the sampling program for each station.

Table 1.--On-station sampling operations (water depth permitting)

1. Expendable bathythermograph drops to 1800 m.
2. Lowering of STD to 1500 m with water samples collected at 12 depths by means of attached rosette sampler.
3. 10-bottle (1.7-liter) cast from 1300 m to near bottom for temperature, salinity, and micronutrient data.
4. 10-bottle (5-liter) cast from surface to near bottom for temperature and salinity data and water samples for analysis of heavy metals and nutrients by EPA.
5. Double oblique tow of "bongo" plankton nets (333- and 505- μ mesh) in the upper 200 m.
6. 10-minute tow of neuston net.
7. Double oblique tow of a 10-foot Isaacs-Kidd Midwater Trawl from 700 m to surface during hours of darkness.
8. Lowering of deep-sea camera to the bottom for a sequence of 10 photographs (after May 15).
9. Collection of water samples at five depths by means of sterile bag samplers for analysis of coliform and fecal bacteria by EPA (after May 15).

RESULTS

Twenty-three stations of the established survey grid of 33 stations were occupied in and near the dumpsite (fig. 2). All the grid stations within the dumpsite were occupied, but 10 stations outside the dumpsite were omitted, because of the loss of two days of ship time from the planned cruise and addition of bottom photography to the mission at the last moment. The pattern of stations occupied yields three sections from shelf to deep water passing through the dumpsite. Table 2 summarizes the data collected on the cruise. Table 3 lists the station positions and times. Processing and analyses of the data and samples collected are being conducted by the cooperating agencies or their contractors.

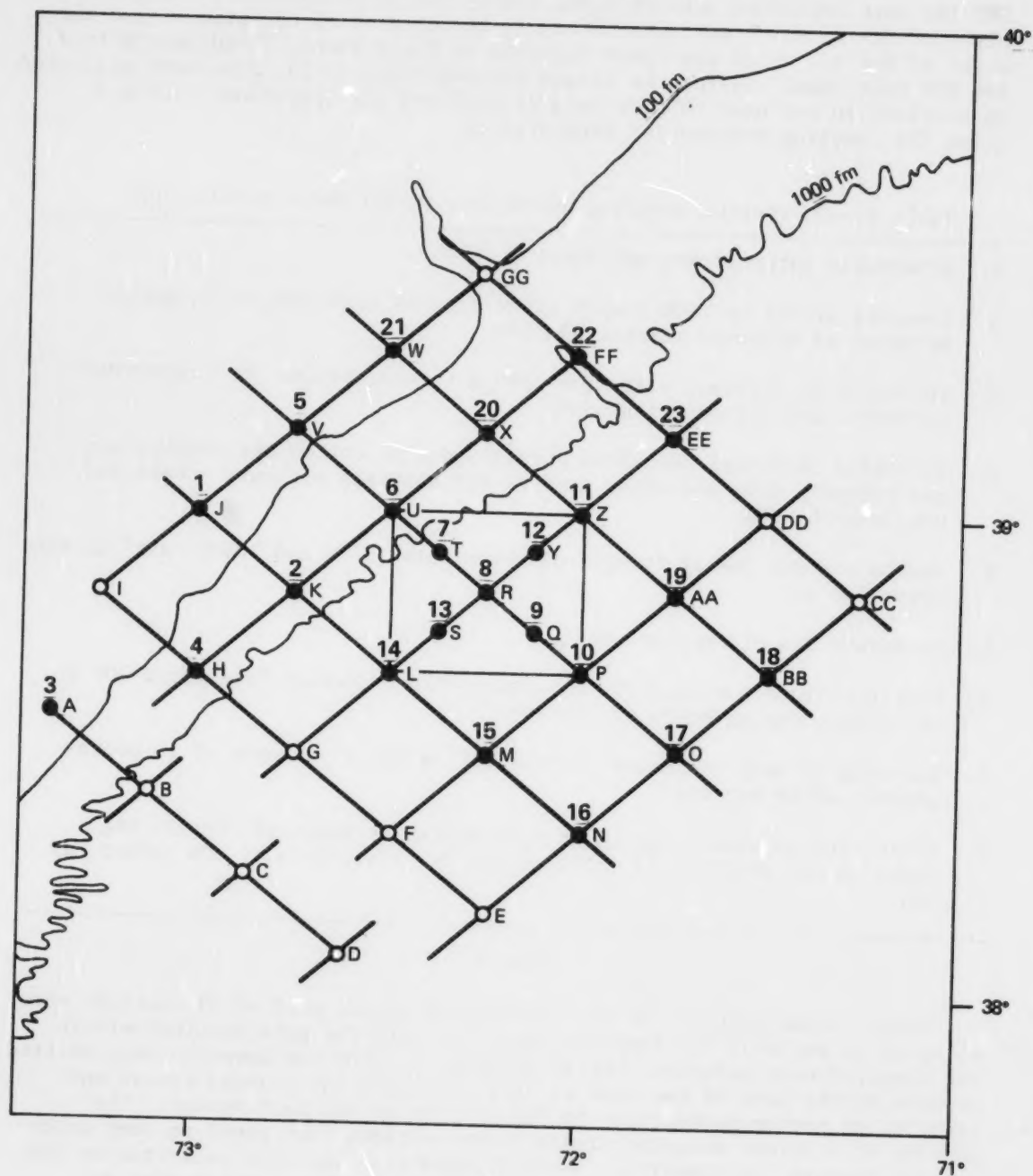


Figure 2.--FRS Albatross IV cruise 74-5 station positions. All circles (open and solid) indicate established survey grid stations identified by letter designations. Solid circles and accompanying number designations indicate the 23 stations occupied in the order of occupation of stations.

Table 2.--Summary of data collected

Operation	Number of stations	Number of records or samples
XBT	23 and other points	99 traces
STD	22	22 traces
		200 O ₂ , nutrients
		60 T, S
Deep hydrographic cast	15	140, T, S, nutrients, metals
5-liter bottle cast	22	200 nutrients, metals, T, S
Bacterial sampler	15	83
Plankton tow	23	46 zooplankton
Neuston tow	23	23
IKMWT tow*	10	9
Bottom photography	13	121 photographs

* Isacss-Kidd Midwater Trawl.

Table 3.--Station letter and number designations, positions, and time of occupation

Station designation		Position		Date	Time
Letter ¹	Number ²	Latitude	Longitude	May 1974	
A	3	38° 35' N	73° 22' W	12	0450
B	--	38 25	73 07	--	--
C	--	38 15	72 52	--	--
D	--	38 05	72 37	--	--
E	--	38 10	72 15	--	--
F	--	38 20	72 30	--	--
G	--	38 30	72 45	--	--
H	4	38 40	73 00	13	1800
I	--	38 50	73 15	--	--
J	1	39 00	73 00	10	2350
K	2	38 50	72 45	11	1755
L	14	38 40	72 30	19,20	1830
M	15	38 30	72 15	20	0740
N	16	38 20	72 00	20,21	1705
O	17	38 30	71 45	21	0228
P	10	38 40	72 00	17,18	1852
Q	9	38 45	72 07	17	0734
R	8	38 50	72 15	16,17	1930
S	13	38 45	72 22	19	0822
T	7	38 55	72 22	16	1040
U	6	39 00	72 30	16	0500
V	5	39 10	72 45	15	2126
W	21	39 20	72 30	22	1944
X	20	39 10	72 15	22	1311
Y	12	38 55	72 07	18	1845
Z	11	39 00	72 00	18	1005
AA	19	38 50	71 45	22	0105
BB	18	38 40	71 30	21	1250
CC	--	38 50	71 16	--	--
DD	--	39 00	71 31	--	--
EE	23	39 10	71 46	23	1210
FF	22	39 20	72 01	23	0405
GG	--	39 30	72 16	--	--

1 Letter designations for established survey grid stations. Only 23 of the established stations were occupied.

2 Number designations of the 23 occupied stations; numbered in order of occupation.

NOTE: FRS Albatross IV cruise 74-5 data tabulations use both letter station designations and number station designations. Figure 2 shows the chart locations of all stations and their letter and number designations.

NOAA SHIP DELAWARE II CRUISE 74-2 REPORT OF MAY 13-21, 1974,
SURVEY OF DEEPWATER DUMPSITE 106

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INTRODUCTION

Cruise 74-2 by NOAA ship Delaware II, and cruise 74-5 by NOAA ship Albatross IV, were part of a joint effort during the May 1974 field investigation of Deepwater Dumpsite 106.

Prior to departure of the Delaware II, the ship's hydrographic winch was tested and found inadequate to lift the Smith-McIntyre bottom grab sampler clear of the deck. Departure was delayed while wire was transferred from the hydrographic winch to the port trawl winch drum. The starboard trawl winch drum was filled with 9/16" trawl wire for deepwater trawling by J. A. Musick, Virginia Institute of Marine Science (VIMS). Following transfer of the wire the Delaware II departed Sandy Hook at 1420, May 13.

After a brief stop at Scotland Light to test the precision depth recorder (PDR) the vessel proceeded to a station near the edge of the continental shelf (54 fm) to test the operation of the Smith-McIntyre bottom grab sampler and the deep-sea trawl to be used by J. A. Musick. A second test station was accomplished in 520 fm of water. The vessel then proceeded to Alvin dive site 3 where Smith-McIntyre and trawl operations commenced as part of the cruise plan. Smith-McIntyre sampling was accomplished at this station. During the trawling operations the hydraulic motor driving the starboard trawl drum became inoperative while the net was being hauled in. This necessitated switching the hydraulic lines from the port hydraulic motor to the starboard drum to retrieve the trawl net. The switching of hydraulic lines by ship's engineers took 3.5 hours. The net was successfully retrieved. Smith-McIntyre sampling was then postponed until completion of all trawl stations. Time required to shift hydraulic lines, and loss of hydraulic fluid, were primary considerations in this decision. Trawl activities then continued at Alvin dive sites 3, 4, 5, around 6, and over 2. Trawl operations were suspended following site 2 on May 17 because of the increasing realization that the only remaining main trawl winch motor would not operate much longer under the strain of deep-sea trawling. At this point, the hydraulic lines were shifted from the starboard drum back to the

port drum to allow Smith-McIntyre operations. Smith-McIntyre bottom grab sampling commenced at Alvin dive site 1 and proceeded to Alvin dive sites 2, 4, 5, 7, and 6. At site 4 the Smith-McIntyre grab was run into the block and lost. The loss can be attributed to use of a main trawl winch that was hard to control instead of a suitable oceanographic winch. A second Smith McIntyre grab was put into use and sampling continued uneventfully. Additional Smith-McIntyre samples were collected in the disposal area for detection of possible radioactive wastes by EPA personnel on board (see report on investigation of radioactivity by Robert Dyer). A final Smith-McIntyre bottom grab sample was taken at Alvin site 3 at 1700 on May 20. From there the vessel proceeded to Sandy Hook, arriving at 0615 on May 21.

CRUISE OBJECTIVES AND PERSONNEL

Objectives of the cruise were to study the chemical, biological, and geological characteristics of Deepwater Dumpsite 106, particularly during the spring season, and to use the data in preparing an environmental impact statement for DWD 106. Equipment used to collect the data included deep-sea trawls, Smith-McIntyre bottom grab samplers, precision depth recorder, and expendable bathythermographs (XBTs). These data are being analyzed to assess the distribution and abundance of benthic biota, the distribution and concentration of heavy metals in benthic biota and sediments, the grain-size characteristics and distribution of sediments, the fate of containerized radioactive wastes disposed of at 38°30'N, 72°6'W, and the seasonal temperature structure of the water column and movements of the deep scattering layer. Scientific personnel included:

J. P. Thomas, Party Chief, NMFS, Smith-McIntyre
Phoel, NMFS, Smith-McIntyre
J. A. Musick, VIMS, Deep-sea trawl
D. Markle, VIMS, Deep-sea trawl
C. Wenner, VIMS, Deep-sea trawl
G. Sedberry, VIMS, Deep-sea trawl
R. Dyer, EPA, Radioactive Monitoring
Phillips, EPA, Radioactive Monitoring

The cruise report consists of three parts: Two parts, deep-sea trawling and Smith-McIntyre bottom grab sampling, are discussed here. The third part, the sampling program to study the fate of radioactive wastes, is a separate report by Robert Dyer titled "Investigation of radioactive waste disposal--sampling program." The deep-sea trawling report by J.A. Musick of VIMS follows.

DEEP-SEA TRAWLING

The study of archibenthic and abyssobenthic fishes of the deepwater dumpsite and adjacent area will describe the relative abundance, community structure, reproductive biology, and food habits of fishes. During the May 1974 survey this effort was supervised by J. A. Musick of VIMS. D. Markle, G. Sedberry, and C. Wenner were participating scientists.

Work accomplished: Trawling commenced on May 14 at 0030 hours. A total of 17 trawls was attempted (table 1). The first three trawls were made to coordinate the peculiar fishing attributes of our 45-foot bridled trawl and the fishing characteristics of the Delaware II. The net failed to make contact with the bottom in 55 fm because of excessive ship speed at Station 1. This problem was rectified and all successive trawls, even as deep as 1500 fm, gave evidence of bottom contact (collections of benthic animals, mud on doors and bridles, etc.). The first two trawls at Alvin site 4 resulted in the destruction of two nets by ship wreckage and rough bottom. Trawl stations were added west (Station 4B), southwest (Station 4C) and east (Station 10) of Alvin Station 4 and DWD 106 to replace the aborted trawls at 4. Stations 4B, 4C, and 10 occupied about the same bathymetric region as Station 4 and should give some estimate of fish communities at Station 4. Stations 6, 6A and 6B were located on the south, east, and north of Alvin site 6 in the radiological dumpsite because no trawling was allowed at the site Alvin 6. These trawls were made to characterize the fish fauna near site 6 and to provide Robert Dyer, the EPA representative aboard, with material for radiological analyses. Trawling operations were suspended after trawl station Alvin 2 where the trawl "hung up" in clay bottom and put a severe strain on the only operational oceanographic and trawl winch aboard. The trawl was successfully retrieved with catch intact. However, because the Smith-McIntyre bottom grab sampler operation depended on the same winch motor, trawling was suspended rather than jeopardizing the benthic infaunal survey.

At all trawl stations each fish was identified, measured, and weighed by species. Gonads, stomach contents, and specimens infected with parasites were preserved for study. Biomass of invertebrates was noted and subsamples were preserved. All Geryon (red crabs) were measured, sexed, and weighed. A large sample of these were subjected to organoleptic analysis. Specimens of dominant species were frozen for analyses of heavy metals. Specimens of both fishes and invertebrates were provided to EPA personnel aboard for radiological analyses.

Conclusions: Because the PDR provided on this cruise did not operate properly, all depths beyond 840 fm (the range of the SIMRAD recorder on board) were estimated from navigational charts. A permanent PDR, PGR, or PESR should be installed on Delaware II. The use of a "Fish" transducer is undependable, is time consuming, and is impossible to use in rough weather. The oceanographic winch provided for bottom grab collections was insufficiently powered to lift the weight of the grabs. Consequently the grab wire had to be jerry-rigged onto one of the main trawl winches. This situation led to the loss of one Smith-McIntyre grab because the large drum, high speed, and high power of the trawl winch resulted in a lifting system that was very difficult to control by the winch operator. In the future an oceanographic winch suitable for deepwater bottom sampler work should be installed on Delaware II.

One main trawl winch motor broke down completely during station 3B and the hydraulic system from the other motor had to be switched over in order to retrieve the trawl. The only remaining winch motor became increas-

Table 1.--Deep-sea trawling station data

Trawl station number	Date May 1974	Time	Position	Depth (fm)	Designation
1	14	0130-0133	39°30'N, 72°34'W - 39°27'N, 72°33'W	55	Shakedown
1A	14	0215-0245	39°27'N, 72°35'W - 39°25'N, 72°37'W	55	Shakedown
2	14	1008-1108	39°09'N, 72°19.5'W - 30°08'N, 72°22'W	490-530	Shakedown
3	14	1719-1819	39°04'N, 72°32'W - 39°00'N, 72°32.5'W	500-750	Alvin 3
3A	14	2100-2200	39°02'N, 72°29'W - 38°59.5'N, 72°26.5'W	620-840	Alvin 3
3B	15	0106-0206	39°02'N, 72°25'W - 39°00'N, 72°26'W	520-800	Alvin 3
4	15	0926-1026	38°52'N, 72°16.5'W - 38°50'N, 72°14.5'W	~1300	Alvin 4
4A	15	1651-1751	38°47'N, 72°11'W - 38°47'N, 72°16'W	~1400	Alvin 4
5	15	2217-2317	38°35'N, 72°23'W - 38°32.5'N, 72°23'W	~1350-1480	Alvin 5
5A	16	0203-0303		~1500	Between Alvin 5 and Alvin 6
6	16	0735-0905	38°18'N, 72°03'W - 38°19'N, 71°57'W	~1500	South of Alvin 6
6A	16	1215-1315	38°28'N, 71°55'W - 39°29'N, 71°52.5'W	~1500	West of Alvin 6
6B	16	1657-1757	38°38'N, 72°06'W - 38°39'N, 72°10'W	~1300	North of Alvin 6
4B	16	2300-0000	38°50'N, 72°34.5'W - 38°48'N, 72°34.5'W	~1100-1230	West of Alvin 4
4C	17	0356-0456	38°43'N, 72°30'W - 38°42.5'N, 72°27'W	~1300	Southwest of Alvin
10	17	1020-1120	39°03'N, 71°47'W - 39°04.5'N, 71°45'W	~1200	Between Alvin 4 and Alvin 7
Alvin 2	17	1522-1622	39°10'N, 72°50.5'W - 39°08'N, 71°48.5'W	~1250	Alvin 2

ingly erratic in operation and finally when the trawl "hung up" at station Alvin 2 the winch motor could not lift the net free or even break the bridle wire. Finally through accomplished ship handling the trawl was retrieved. As a consequence, trawling activities had to be terminated in order to prevent jeopardizing the remainder of the cruise. The main trawl winches are obviously in need of overhaul.

Mechanical provisions on the ship were inadequate. Cooperation by the ship's officers and crew were excellent. The ultimate success of this mission can be attributed to the perseverance, expertise, and help of the personnel of the Delaware II and the Sandy Hook Marine Laboratory.

SMITH-MCINTYRE BOTTOM GRAB SAMPLING

Bottom grab samples and their analyses will provide information on the chemical, biological, and geological characteristics of Deepwater Dumpsite 106 and the adjacent area, including the distribution and abundance of benthic fauna, distribution and concentration of heavy metals in sediments, grain-size characteristics of sediments, and presence of radioactive materials.

At least two Smith-McIntyre bottom grab samples were taken at each station (table 2). The second or third sample taken at a station is the best, quantitatively, because it has the least material removed from it as aliquots for analyses for the presence of radioactive materials (table 3). Each grab sample from the radioactive waste disposal area was scanned with a portable Geiger survey meter before the sample was handled. Then four (occasionally five) cores were removed from near the center of the sample. Three of the cores were taken with 38-mm (1.5-inch) diameter plastic core liners. These cores were labeled and frozen for future analyses for heavy metals, mechanical properties of sediment, and radioactive materials. The fourth core was taken with a 25-mm (1.0-inch) diameter plastic tube to a depth of approximately 5-cm. The sample was placed in a labeled jar containing formalin and a piece of clam shell and stored for meiofaunal examination. An additional 400-ml sediment sample (covering about one-quarter of the grab surface area) was removed from the first grab sample by EPA personnel for their analyses. In some cases more than one core or more than one 400-ml sediment sample was removed from the grab sample (table 3). In such cases the grab sample was not saved for macrofauna. Otherwise the remainder of the Smith-McIntyre grab sample was removed from the grab and washed through standard geological screens (1-mm and 0.5-mm). The material trapped on the individual screens was placed in separately labeled jars and preserved with formalin for macrofaunal examination.

Twenty-seven Smith-McIntyre bottom grab samples were taken at 16 stations (table 3). The first three stations were test stations for the operation of the gear. Seven of the stations corresponded with the seven

Table 2.--Stations sampled by Smith-McIntyre bottom grab sampler

Station	Alvin Site	Latitude	Longitude
1	-	39°32'N	72°32'W
2	-	38°11'B	62°15'W
1	1	39°46'N	70°40'W
2	2	39°101'N	71°50'W
3	3	38°57'N	72°29'W
4	4	38°51'N	72°16'W
5	5	38°42'N	72°22'W
6	6	38°30'N	72°06'W
7	7	39°05'N	71°40'W
NW6	-	38°33'N	72°10'W
N6	-	38°34'N	72°06'W
W6	-	38°30'N	72°11.5'W
SW6	-	38°26.5'N	72°11'W
S6	-	38°26.5'N	72°07'W
E6	-	38°29'N	72°00'W

proposed Alvin dive sites; six stations were added specifically to help characterize radioactivity in sediments from the disposal area used for radioactive wastes. The grab samples yielded 26 cores each for heavy metal analyses and sediment parameters. Thirty-three cores were taken from grab samples for radiation analyses by EPA. Twenty-four subsamples were taken for meiofaunal investigation. Twenty-six sediment subsamples of 400-ml size were taken for radiation analyses. Twenty-two samples each of material greater than 1-mm and greater than 0.5-mm were taken for macrofaunal examination. Twenty-three samples of biota for heavy metal analyses were taken from J. A. Musick's deep-sea trawl (table 4). XBT were dropped eleven times during the cruise. Data is available for proposed Alvin dive sites 1, 3, 4, 5, 6, and 7. The PDR "Fish" transducer struck the hull of the vessel and was damaged at the first station. Without spare parts and an electronics technician the PDR proved to be beyond repair capabilities on this cruise. Because of this, no monitoring of the deep-scattering layer was achieved.

Table 3.-- List of samples obtained from Smith-McIntyre bottom grab sampling

Station	Alvin site	Date		Grab No.	Heavy metals	Grain size	Radiation		Faunal		
		May 1974	Time				sedi-ment	400-ml bulk	meio.	>1	>.5
SH dock	-	13	1400	1	-	-	1	1	-	-	-
1	-	13	2305	1	1	1	1	1	-	1	1
				2	1	1	1	1	-	1	1
2	-	14	0500	1	1	1	1	1	1	1	1
				2	1	1	1	1	1	1	1
3	3	14	1307	1	1	1	1	1	1	1	1
				2	1	1	1	1	1	1	1
		20	1630	3	-	-	-	-	-	-	-
1	1 std.	18	0035	1	1	1	1	1	1	1	1
				2	1	1	1	-	1	1	1
2	2 std.	18	0810	1	1	1	1	1	1	1	1
				2	1	1	1	-	1	1	1
4	4	18	1704	1	1	1	1	1	1	1	1
				2	1	1	1	-	1	1	1
5	5	19	0207	1	1	1	1	1	1	1	1
				2	1	1	1	-	1	1	1
7	7	19	0855	1	1	1	1	1	1	1	1
				2	1	1	1	-	1	1	1
6	6	20	0154	1	1	1	1	1	1	1	1
				2	1	1	1	1	1	1	1
		20	0940	3	1	1	1	-	1	1	1
NW6	-	19	2130	1	1	1	2	2	1	*1	*1
N6	-	20	0010	1	1	1	2	2	1	-	-
W6	-	20	0440	1	1	1	2	2	1	-	-
SW6	-	20	0615	1	1	1	2	2	1	-	-
S6	-	20	0800	1	1	1	2	2	1	-	-
E6	-	20	1212	1	1	1	2	2	1	-	-

* Probably no good because radiation bulk sample removed all surface of sample

Table 4.--Samples of biota taken from deep-sea trawl for heavy metal analyses

Trawl station number	Sample	Trawl station number	Sample
1A	Butterfish - <u>Peprilus triacanthus</u>	4B	<u>Benthodites giganteus</u>
	Whiting - <u>Merluccius bilinearis</u>		<u>Alepocephalus agassize</u>
	Gadidae - <u>Phycis chesteri</u>	4C	<u>Nematonurus armatus</u>
	Macrouridae - <u>Nezumia bairdi</u>	5	Starfish
	<u>Glyptocephalus cynoglossus</u>	6A	<u>Nematonurus armatus</u> with viscera
	<u>Coryphaenoides rupestris</u>		<u>Nematonurus armatus</u> eviscerated
3B	Red crab - <u>Geryon quinquedens</u>		<u>Nematonurus armatus</u> with organs
	<u>Alepocephalus agassizi</u>		
	<u>Nezumia bairdi</u>		
	<u>Dicrolene intronigra</u>		
	<u>Synaphobranchus kaupi</u>		
	<u>Synaphobranchus kaupi</u>	6B	Starfish
4	clay clumps from trawl		480 gms Starfish
			<u>Halosauropsis macrochir</u>
			<u>Nematonurus armatus</u>

INVESTIGATION OF RADIOACTIVE WASTE DISPOSAL AT DEEPWATER DUMPSITE 106

--SAMPLING PROGRAM MAY 1974¹

Robert Dyer, Oceanographer

Office of Radiation Programs
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Washington, D.C. 20460

INTRODUCTION

This report describes the sediment and biota sampling program to determine the fate of radioactive wastes at Deepwater Dumpsite 106 (DWD 106) during the May 1974 field investigation. The primary objective was to investigate a deepwater radioactive waste disposal site approximately 10 miles square centered on coordinates 38°30'N, 72°06'W. The principal data gathering effort, as outlined in the operations plan for the May 1974 field investigation of DWD 106, was to be performed by the deep submersible Alvin on May 20. Prior to that time, deepwater trawl biological samples and sediment grab samples taken by the Delaware II in adjacent areas (including DWD 106) were to provide background or control levels of radioactivity attributable to naturally occurring and fallout radionuclides. Sediment and biota analysis would also indicate any radionuclide migration or possible disposal outside the dumpsite. The last minute cancellation of the Alvin operation at dive site 6 seriously restricted both the total information to be obtained from this study as well as conclusions drawn from the analytical results obtained from the Delaware II sampling program.

SAMPLE COLLECTION AND ANALYSIS

Attached is a list of the sites sampled. All sites except trawl stations 6, 6A, and 6B represent control sites for biota analysis. All sediment samples analyzed represent control sites except for Smith-McIntyre bottom grab samples in and around station 6 (EPA station numbers 20-28) and sediment taken from a trawl at station 6B. All samples around station 6 represent part of the radioactive dumpsite investigation.

Sediment samples were analyzed for gamma activity using a shielded 3-by 3-inch NaI crystal coupled to a multichannel analyzer. Each sample consisted of 400 ml of sediment counted for 100 minutes with background activity subtracted to yield net counts per 10 kev channel. The data were printed out on paper tape. Selected biota samples were also analyzed for gamma activity. Selected sediment and biota samples were dried and analyzed for alpha and beta activity using an internal proportional counter (IPC).

IPC samples generally were counted for 100 minutes with background subtracted to yield net activity. Most sediment and biota samples required more extensive analysis at EPA's Eastern Environmental Radiation Facility in Montgomery, Ala.

¹ From NOAA ship Delaware II cruise 74-2 report, May 13-21, 1974.

RECOMMENDATIONS

From the outset of the cruise the inoperability of the small Smith-McIntyre hydrowinch and precision depth recorder (PDR), coupled with the loss of one of the main winch motors at station 3, created considerable logistics problems. It was necessary to finish the trawling operations at all stations and then return to each station for grab samples. This required long repeat steaming distances while recognizing that failure of the remaining winch would bring the cruise to a premature finish. In addition, there was no way of determining the position of the trawl or sediment-grab equipment below 860 fathoms owing to failure of the PDR. In spite of these difficulties, the Delaware II phase of the sampling program at the radioactive waste dumpsite was successful. This can be attributed to the excellent response of the crew to each failure of equipment and the resultant logistics problems that arose. For any future deep-sea investigative operation, it would seem imperative that a complete equipment check be performed under operating conditions prior to final departure. Also it must be certain that all equipment specifically directed towards a deepwater operation be in working order. The equipment check should confirm that each winch have at least 500 m of wire in addition to the calculated maximum sampling requirements.

Table 1.--Sediment and biological samples analyzed for radioactivity
aboard ship

Station		Coordinates		Samples analyzed aboard ship		
EPA No.	Dive site No.			Gamma	Alpha	Beta
		Latitude ° 'N	Longitude ° 'W			
SH 1		40 28	74 02	sediment	sediment	sediment
SH 2		29 32	72 32	sediment	sediment	sediment
SH 3		39 11	72 15	sediment	sediment	sediment
SH 4	3	38 56	72 27	sediment	sediment	sediment
				--	coral	coral
SH 5	4	38 47	72 16	sediment	sediment	sediment
SH 8	6	38 19	71 57	fish viscera: <u>Nematonurus armatus</u> fish flesh: <u>Nematonurus armatus</u>	--	--
				fish viscera: <u>Nematonurus armatus</u> starfish viscera	--	--
SH 9	6A	38 29	71 52.5	sediment	--	--
SH 10	6B	38 39	72 10	sediment	--	--
SH 12	4	38 42.5	72 27	sediment		
SH 14	2	39 08	71 48.5	sediment	sediment	
SH 15	1	39 45.5	70 40	sediment		--
SH 16	2	39 11	71 51.5	sediment		--
SH 17	4	38 50.5	72 16	sediment		--
SH 18	5	38 41	72 22	sediment		--
SH 19	7	39 05	71 40	sediment		--
SH 20	6	38 33	72 10	sediment	sediment	sediment
SH 21	6	38 34	72 06	sediment	sediment	sediment
SH 22	6	38 30	72 06	sediment	sediment	sediment
SH 23	6	38 29.5	72 07	sediment	sediment	sediment
SH 24	6	38 30	72 11.5	sediment	sediment	sediment
SH 25	6	38 26.5	72 11	sediment	sediment	sediment
SH 26	6	38 26.5	72 07	sediment	sediment	sediment
SH 27	6	38 29	72 00	sediment	sediment	sediment

Table 2.--Biological specimens collected for analysis of radioactivity
at EPA Eastern Environmental Radiation Facility, Montgomery, Ala.

at EPA Eastern Environmental Radiation Facility, Montgomery, Ala.						
EPA No.	Station		Coordinates		Type of organism	Preservative
	Dive site No.	Latitude	Longitude			
			'N	'W		
SH 2		39 27	72 35	fish, <u>Leprophidium cervinum</u>	50% ETOH	
				fish, <u>Urophycis regius</u>	50% ETOH	
SH 3		39 08	72 22	crab, <u>Cancer borealis</u>	frozen	
				crab, <u>Geryon quinquedens</u>	frozen	
				fish, <u>Nezumia bairai</u>	50% ETOH	
				fish, <u>Phycis chesteri</u>	frozen	
SH 4	3	39 06	72 32.5	fish, <u>Coryphenoides rupestris</u>	frozen	
				sea urchin	50% ETOH	
				sea squirt	50% ETOH	
				holothurian	50% ETOH	
				fish, <u>Coryphonoides rupestris</u>	frozen	
SH 6	5	38 32.5	72 23	fish, <u>Phycis chesteri</u>	frozen	
SH 6	5	38 32.5	72 23	starfish	frozen	
				fish, <u>Nematonurus armatus</u>	frozen	
				holothurian, <u>Euphoronides sp.?</u>	frozen	
SH 8	6	38 19	71 57	sea urchin	50% ETOH	
				fish (viscera) <u>Nematonurus armatus</u>	frozen	
SH 9	6A	38 29	71 52.5	starfish (specimen label accidentally tagged SH 8)	frozen	
				fish, (eviscerated) <u>Nematonurus armatus</u>	frozen	
SH 10	6B	38 39	72 10	sea squirt	frozen	
				starfish	frozen	
				fish, <u>Nematonurus armatus</u>	frozen	
SH 11	4B	38 48	72 34.5	midwater shrimp	50% ETOH	
				holothurian, <u>Benthodites sp.</u>	frozen	
				decapod shrimp, <u>Pentachaeles sp</u>	frozen	

Table 3.--Thirty sediment samples taken from Smith-McIntyre grabs and analyzed for radionuclide content, depth distribution of radionuclides where applicable, and grain-size distribution

EPA station no.	Samples taken
SH 1	1
SH 2- 4	2 at each station
SH 15	1
SH 16	2
SH 17	1
SH 18 - 21	2 at each station
SH 22	1
SH 23	1
SH 24 - 27	2 at each station
SH 28	1

PHOTOGRAPHIC RECONNAISSANCE OF CONTINENTAL SLOPE
AND UPPER CONTINENTAL RISE¹

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DISCUSSION

In May 1974 a series of 11 camera stations were made from Albatross IV on the continental slope and upper continental rise (table 1). The investigation was initiated as a reconnaissance study in preparation for the series of manned submersible investigations by DSV Alvin in September 1974. These dives were not made owing to the breakdown of RV Lulu, the Alvin support vessel. This dive series was rescheduled for July-August 1975. The Albatross IV remote photographic investigations provide photographic reconnaissance for the 1975 dive series.

The purpose of the overall investigation is to better understand the seafloor environment, particularly those aspects which may be important in considering the environmental consequences of deepwater waste disposal.

The upper continental rise is an area of nearly uniform sedimentation. Seismic reflection profiling and deep-sea drilling indicate that this depositional environment has prevailed for more than 20 million years. Echograms obtained with the 3.5-kHz (sediment probe) echo sounder reveal a detailed stratification of the uppermost strata and indicate that this stable environment continued through the last thousand years. Photographs of the upper continental rise surface are completely consistent with this view. Most photographs obtained by Albatross IV were taken on the upper continental rise and indicate a tranquil, almost current-free, environment.

The lower continental rise is an area of many current-induced bedforms that produce a variety of patterns on echograms. This feature lies below approximately 1,900 fathoms and is not included within the scope of this report. The many current forms observed on the lower continental rise result from the activity of the Western Atlantic Undercurrent.

¹ Final report of July 1975 to the National Oceanic and Atmospheric Administration under Grant NOAA-01-5-022-591.

Table 1.--May 1974 RFS Albatross IV camera stations

Station	Depth	Latitude	Longitude
	meters		
K-1	665	39 60 N	72 30 W
K-2	991	38 52 N	72 20 W
K-3	1318	38 50 N	72 15 W
K-5	1224	39 00 N	72 00 W
K-6	1235	38 55 N	72 07 W
K-7	1357	38 45 N	72 22 W
K-8	1477	38 32 N	74 45 W
K-9	1424	38 40 N	71 30 W
K-11	450	39 10 N	72 13 W
K-12	878	39 20 N	71 58 W
K-13	1237	39 10 N	71 46 W

The upper continental rise lies below the foot of the continental slope. Echograms from the boundary between these major physiographic features show bedforms which, although not as dramatic as those of the lower continental rise, are nevertheless indicative of considerable erosion. Camera stations K-3 and K-7, which revealed evidence of slumping and erosion, were located in the vicinity of scour channels observed on echograms. Unfortunately, the Albatross IV did not have a recording echo sounder at the time of the 1974 survey and correlation of photographs with echogram character had to be accomplished by study of records obtained nearby during previous research cruises. Photographs of the continental slope generally show a soft sediment covered bottom devoid, or nearly devoid, of competent currents. In the canyons and gullies that incise the continental slope, rocks can be seen along with consolidated and semiconsolidated sediment outcrops. Tidal currents have been observed eroding the canyon floors.

In areas between canyons the continental slope is a remarkably tranquil region; photographs similar to those in this report are typical.

The photographic coverage has been extended beyond the Albatross IV remote observations by including a series of photographs taken during an RV Trident cruise in 1966--camera stations identified by letter T on index map (fig. 7).

CONCLUSIONS

The upper continental rise appears to be a remarkably tranquil area of deposition. This environment has prevailed for more than 20 million years and it seems likely that it will continue to be tranquil in the dumpsite area during the immediate geological future.

Table 2.--List of illustrations

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1.	Directions and strength of western boundary undercurrents	
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The lower continental rise is an area of shifting deposition whereas the transition zone between the two provinces is an area of erosion.

Evidence of erosion and slumping is found at the base of the continental slope. Here the echogram hyperbolae suggest a pattern related to contour current action. This could be significant for the fate of material placed on the sea floor in this environment.

The assembled data in this report are intended as background material for the manned dive series to investigate the area of the deepwater dumpsite. Further discussion of the data and interpretation of the visual patterns awaits completion of the 1975 dive series.

ACKNOWLEDGMENTS

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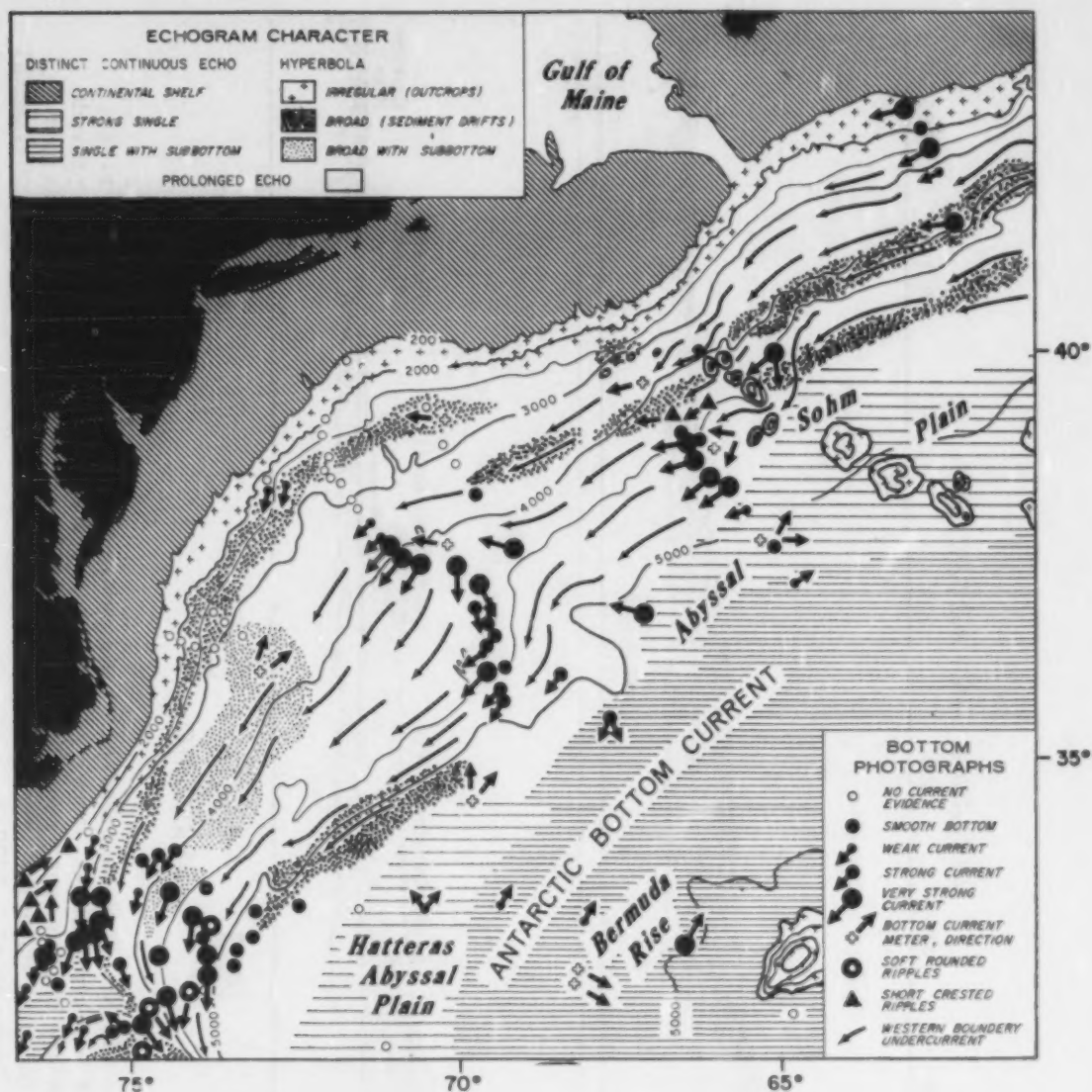


Figure 1.--Direction and strength of Western Boundary Undercurrent inferred from bottom photographs. Above 3500 meters, photographs indicate tranquil, current-free bottom. Below 3500 meters, swift contour currents appear to transport sediment towards the south. Photographs of Hatteras Abyssal Plain show tranquil bottom or variable weak northerly flowing currents. Photographs of the Western Bermuda Rise show the swifter northerly flow of the Antarctic Bottom Current. The Gulf Stream, not shown, apparently reaches the bottom, at least occasionally, in abyssal depths. Photographs, taken beneath the surface axis, often show evidence of a north to northeasterly flow. Bottom soundings have strong coherent echos from the continental shelf and abyssal plains. On the continental rise zones of prolonged echoes and hyperbola trend parallel to the regional contours. (Contours in meters.)

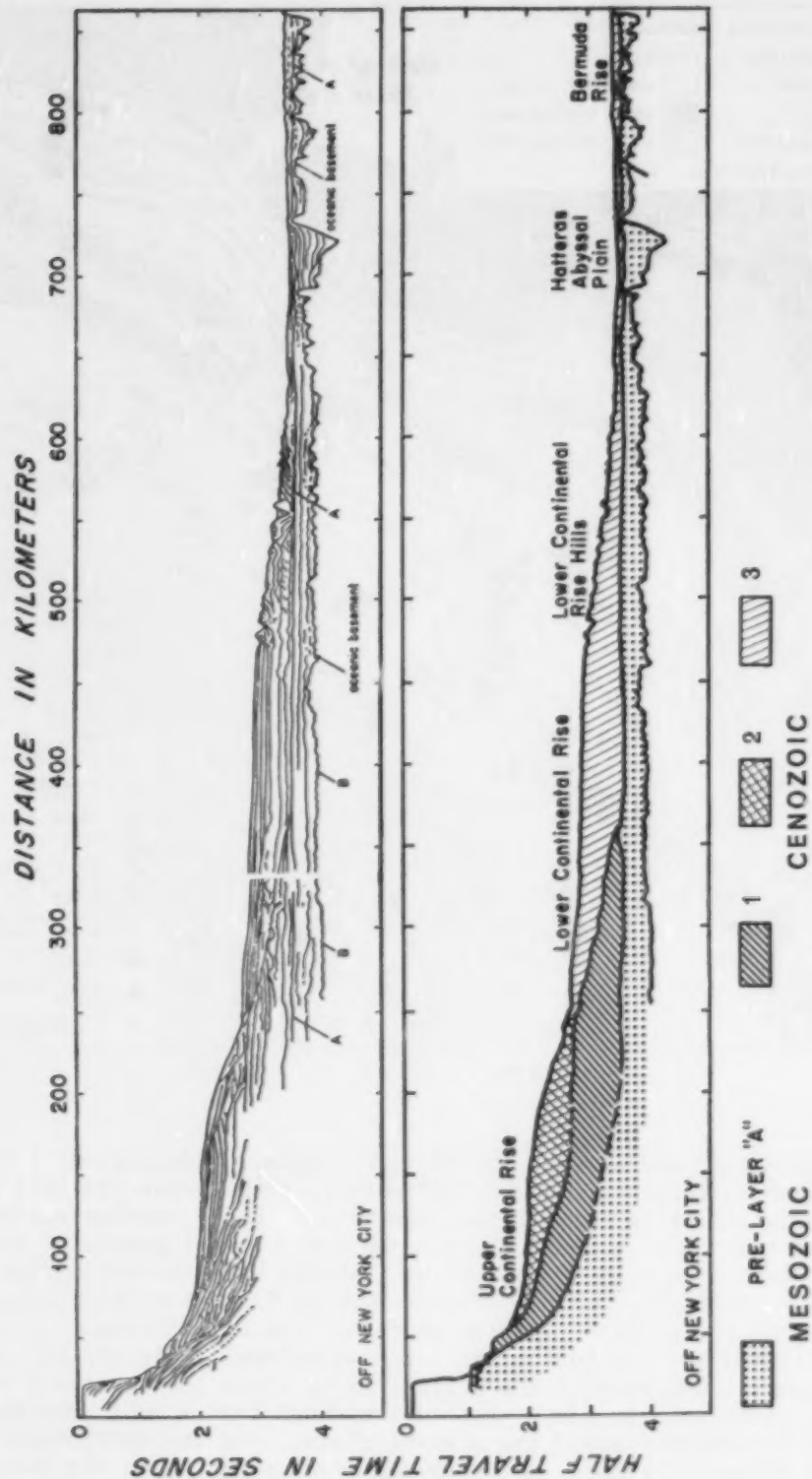


Figure 2.--The continental rise off New York is composed of a seaward-migrating progression of rises stacked against the base of the continental slope. Turbidity currents and pelagic sources provide sediment. The Western Boundary Undercurrent subsequently and penicontemporaneously smooths and shapes, and occasionally erodes or deposits, the fine-grained hemipelagic sediment of the continental rise. (Upper profile from Emery et al., 1970.)

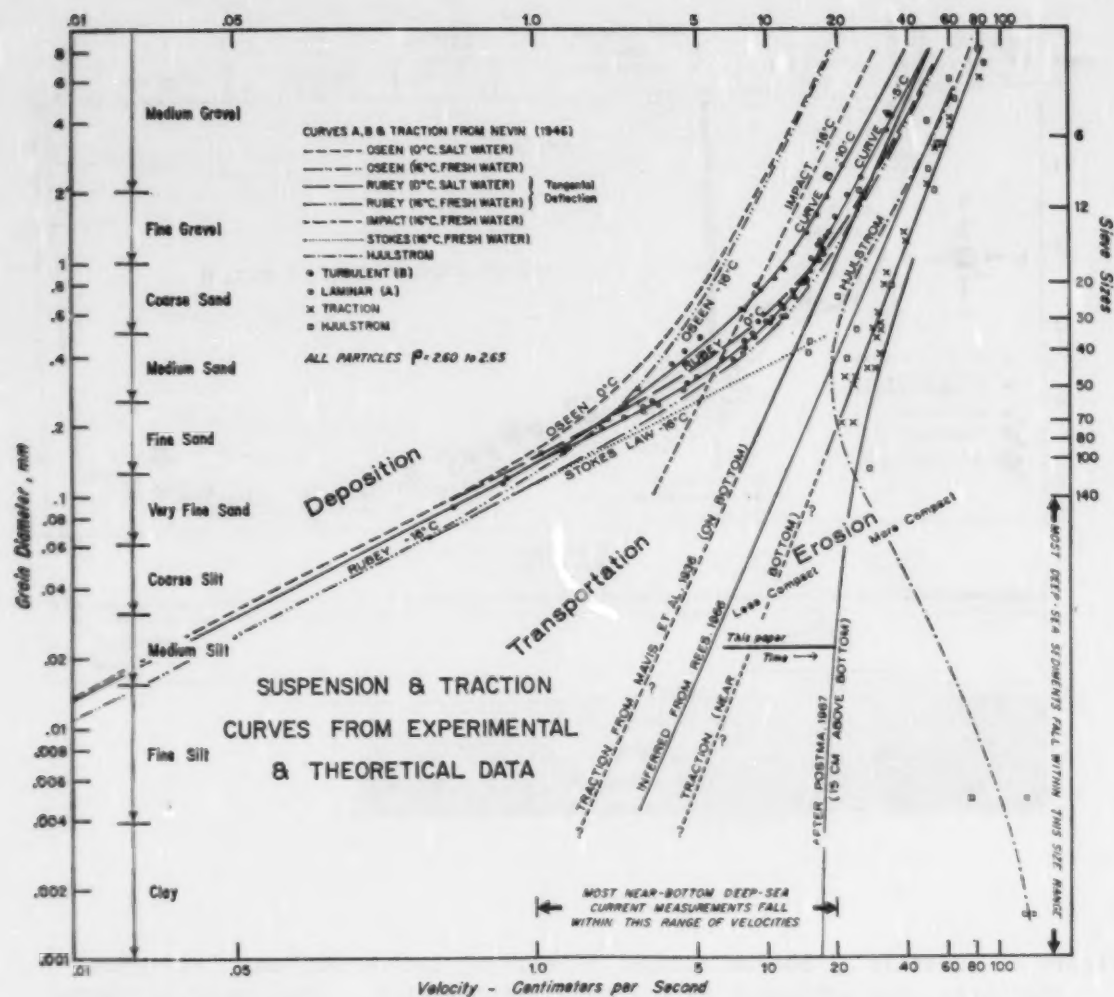


Figure 3.--Current velocities required for erosion, transport, and deposition of stream bed materials--from equations determined theoretically and empirically. Experiments indicate that traction transport of medium silt-sized material can occur at velocities above about 7 cm/sec. (Redrawn from Heezen and Hollister, 1964)

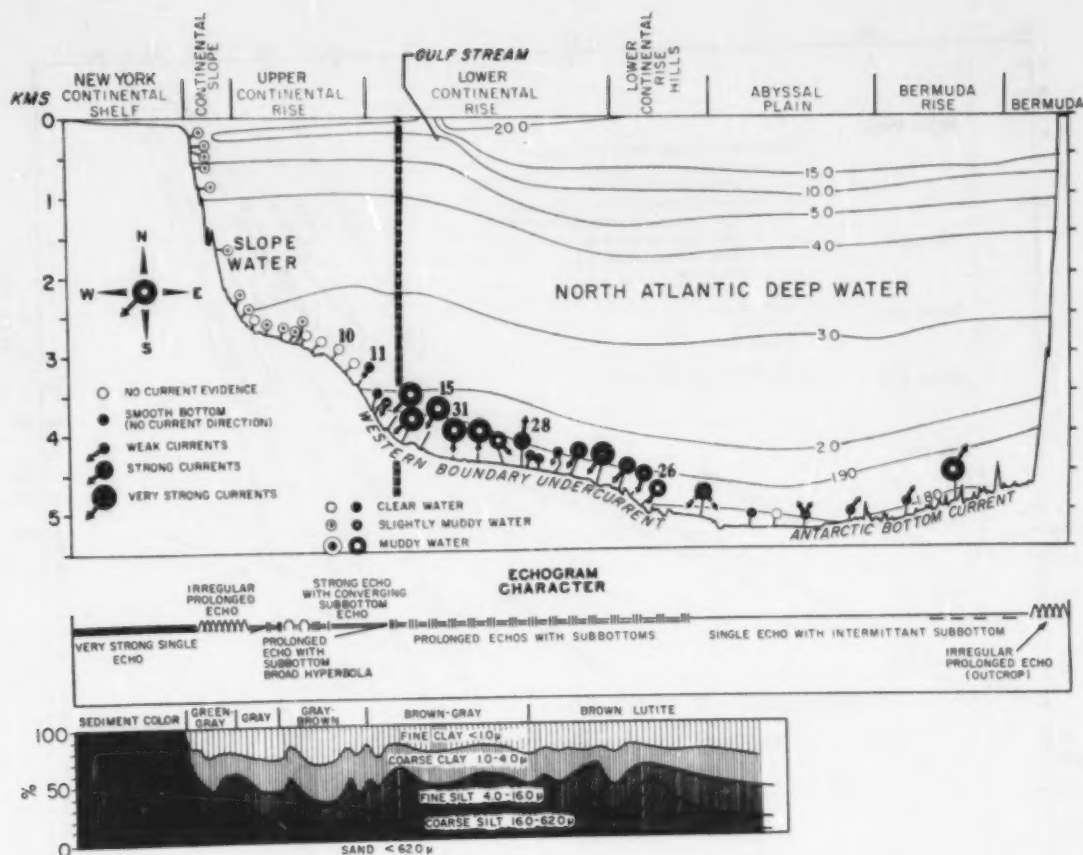


Figure 4.--Profile of bottom current direction, bottom sediment, echogram character, and isotherms of potential temperature. Cold water isotherms lap up on the continental rise (temperature 2.00°C) and on the Bermuda Rise (temperature 1.80°C). Strong ocean currents occur at the break in slope between the upper and lower continental rise, in the hills of the lower continental rise, and above 5000 m on the Bermuda Rise. Prolonged bottom echo sequences and an increase in the surface sand- and silt-sized sediments are associated with current-swept zones on the lower continental rise.

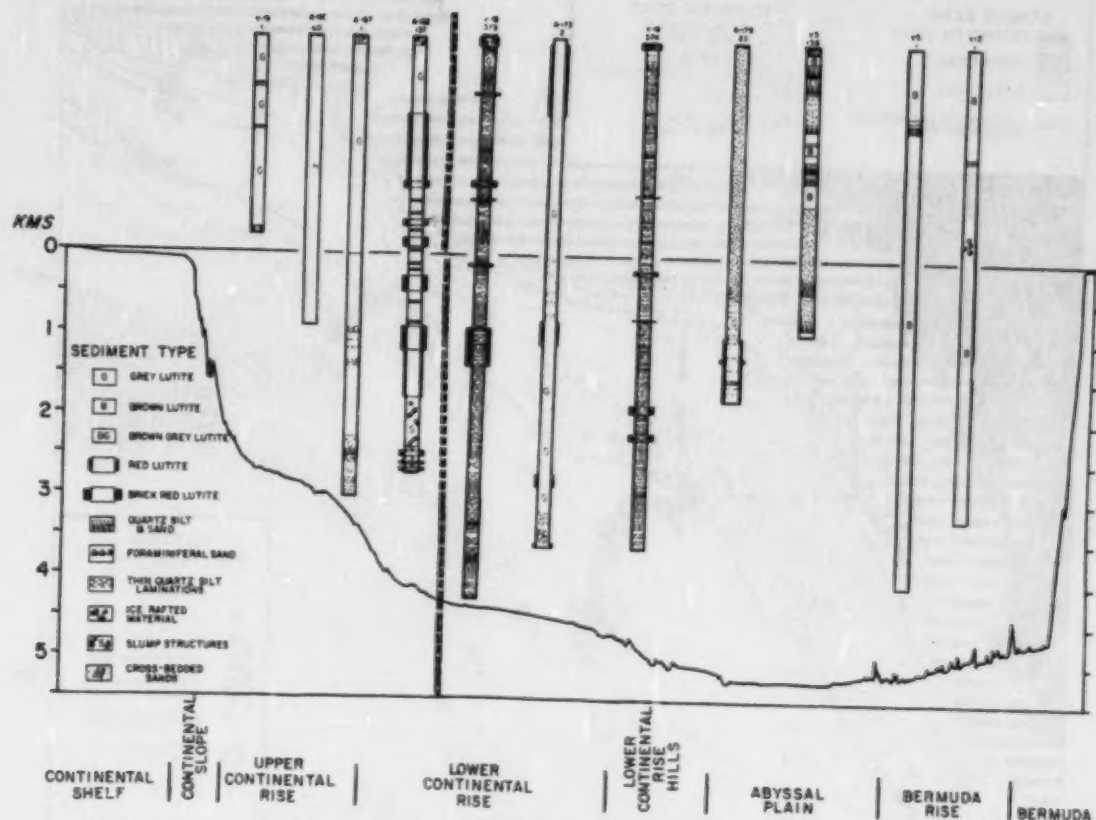


Figure 5.--Lithology of sediment cores from upper and lower continental rise, abyssal plain, and Bermuda Rise--between New York and Bermuda. Homogeneous gray silty lutites lie on upper continental rise. The lower continental rise is typified by many well-sorted thin silt beds and marked zones of red lutite that have been transported south by contour currents from the Gulf of St. Lawrence region. The abyssal plains have thick, poorly sorted, graded sand and silt beds intercalated with brown lutites. Cores from the Bermuda Rise contain homogeneous brown lutites.

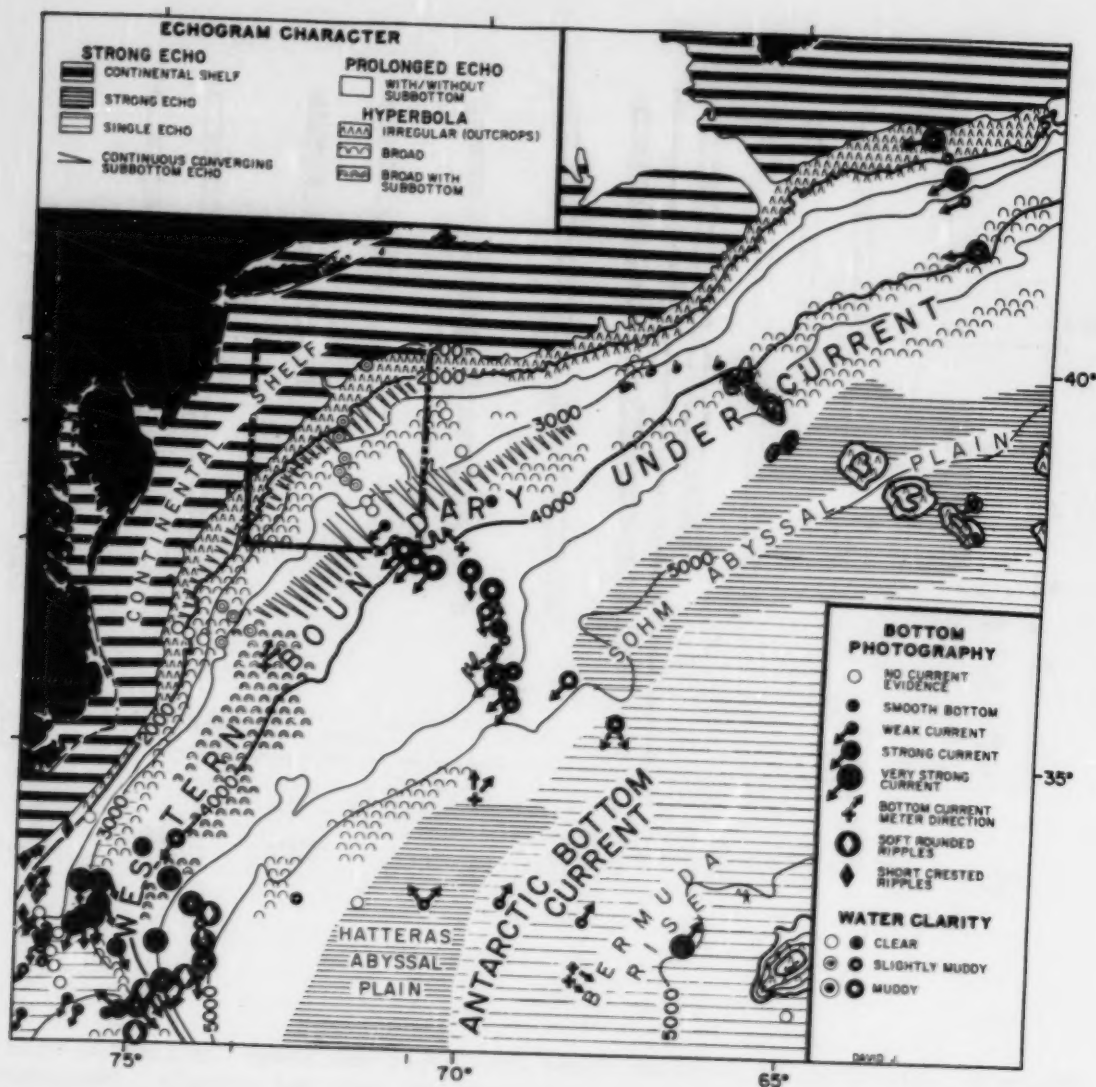


Figure 6.--Sediment transport direction and microphysiography of the Atlantic margin of the United States. The continental shelf and abyssal plains are typified by strong coherent echo returns. On the continental rise, zones of prolonged echoes and hyperbolae trend parallel to the regional contours. Bottom photographs above 3500 meters, show tranquil, current-free bottom. Below 3500 meters, swift contour currents transport sediment. Current-controlled sedimentation appears to have shaped the continental rise and Blake-Bahama Outer Ridge. Photographs of the Hatteras Abyssal Plain show tranquil sea bottoms or variable weak northerly flowing currents. The swifter northerly flow of Antarctic Bottom Water is observed on the Western Bermuda Rise. Rectangle indicates area shown in figure 7. (Contours in meters.)

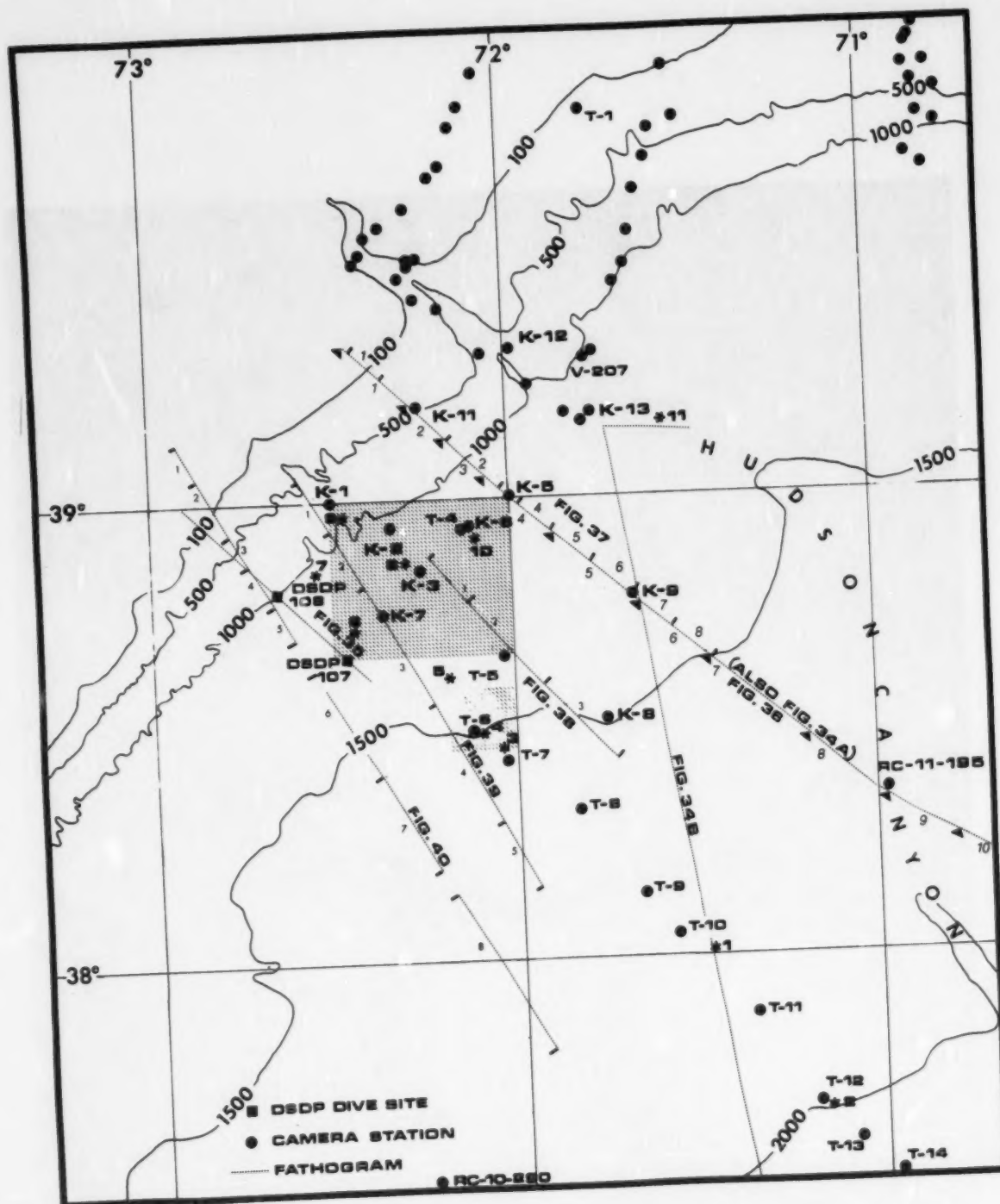


Figure 7.--Index map of Albatross (K) and Trident (T) camera stations, Deep-Sea Drilling Project sites 107 and 108, and echogram profiles. Shaded area is rectangle identified by heavy dashed lines in figure 6.

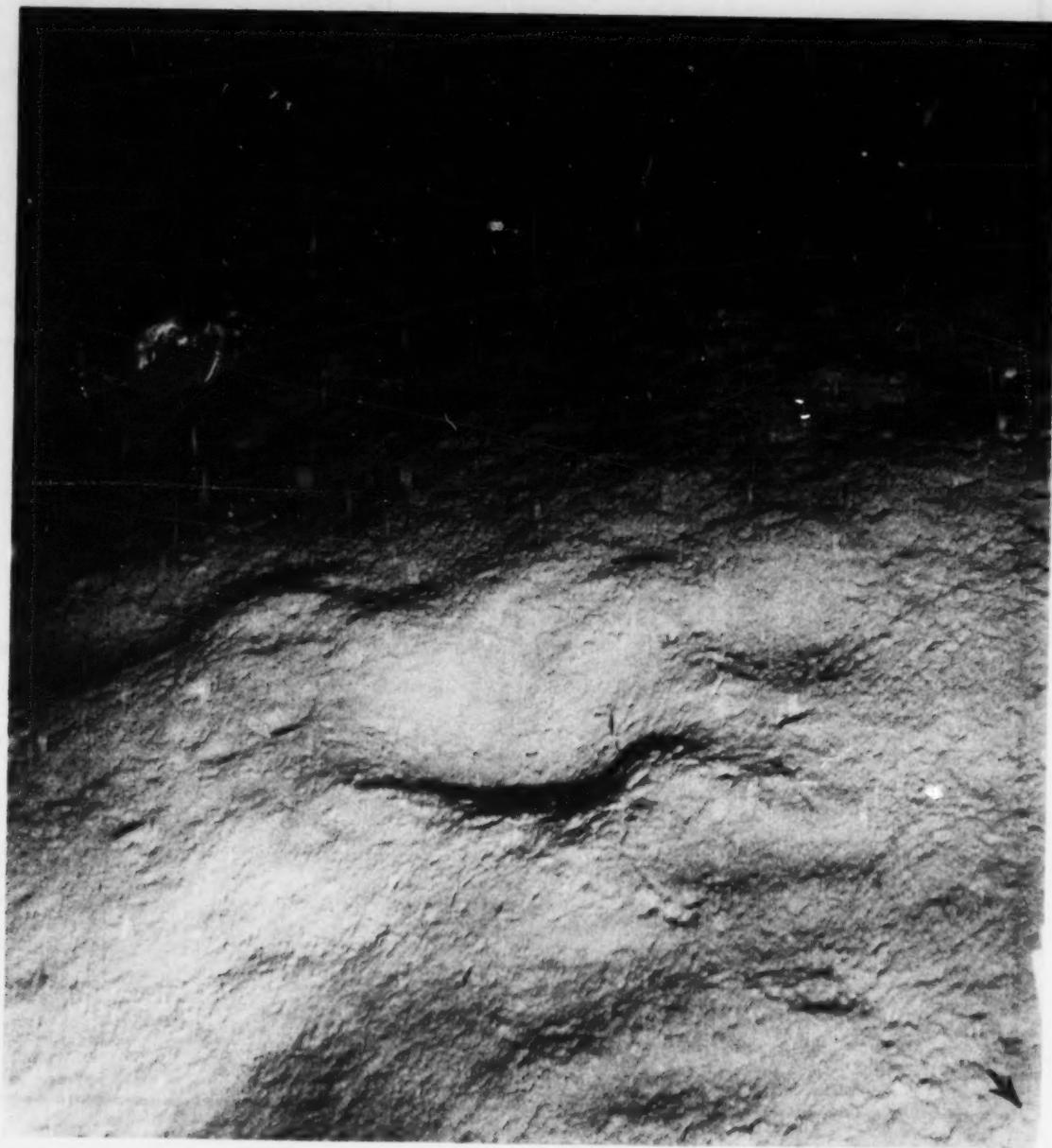


Figure 8.--Upper continental slope is generally covered with soft pitted sediment. Crabs are common. Camera station K-11; 450 fathoms; $39^{\circ}10'N$, $72^{\circ}13'W$.

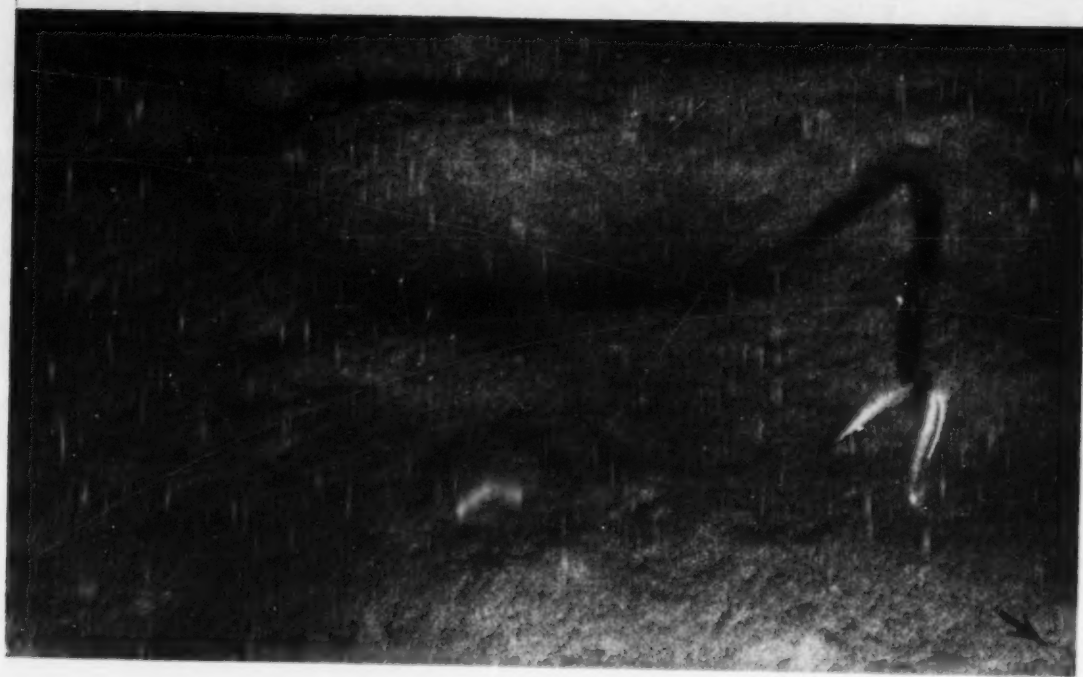


Figure 9.--Soft hemipelagic sediment covers upper continental slope. Armoured worm tubes are locally common. Upper: Camera station T-1; 202 fathoms; 39°50'N, 71°45'W. Lower: K-11; 450 fms; 39°10'N, 72°13'W.



Figure 10.--Upper continental slope, showing locomotion and burrow marks.
Camera station K-1; 665 fathoms; $39^{\circ}60'N$, $72^{\circ}30'W$.



Figure 11.--Ophiuroids and asteroids are common on the continental slope.
Camera station K-12; 878 fathoms; 39°20'N, 71°58'W.



Figure 12.--Corroded drum lies on lower continental slope near DWD 106.
Camera station K-2; 991 fathoms; 38°50'N, 72°20'W.

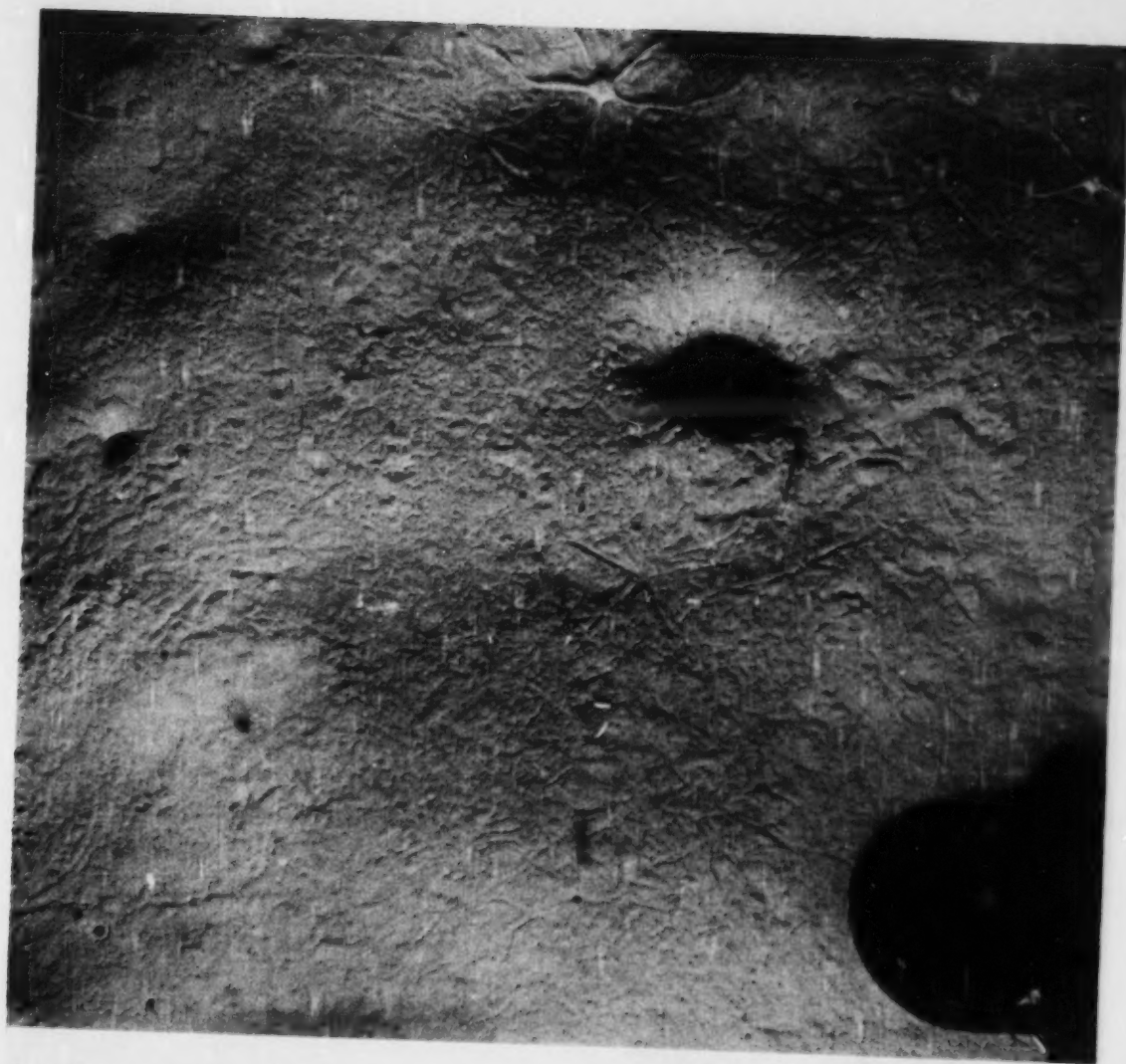


Figure 13.--Fine bioturbations are common near base of continental slope.
Camera station V-207; 1077 fathoms; 39°18'N, 71°47'W.

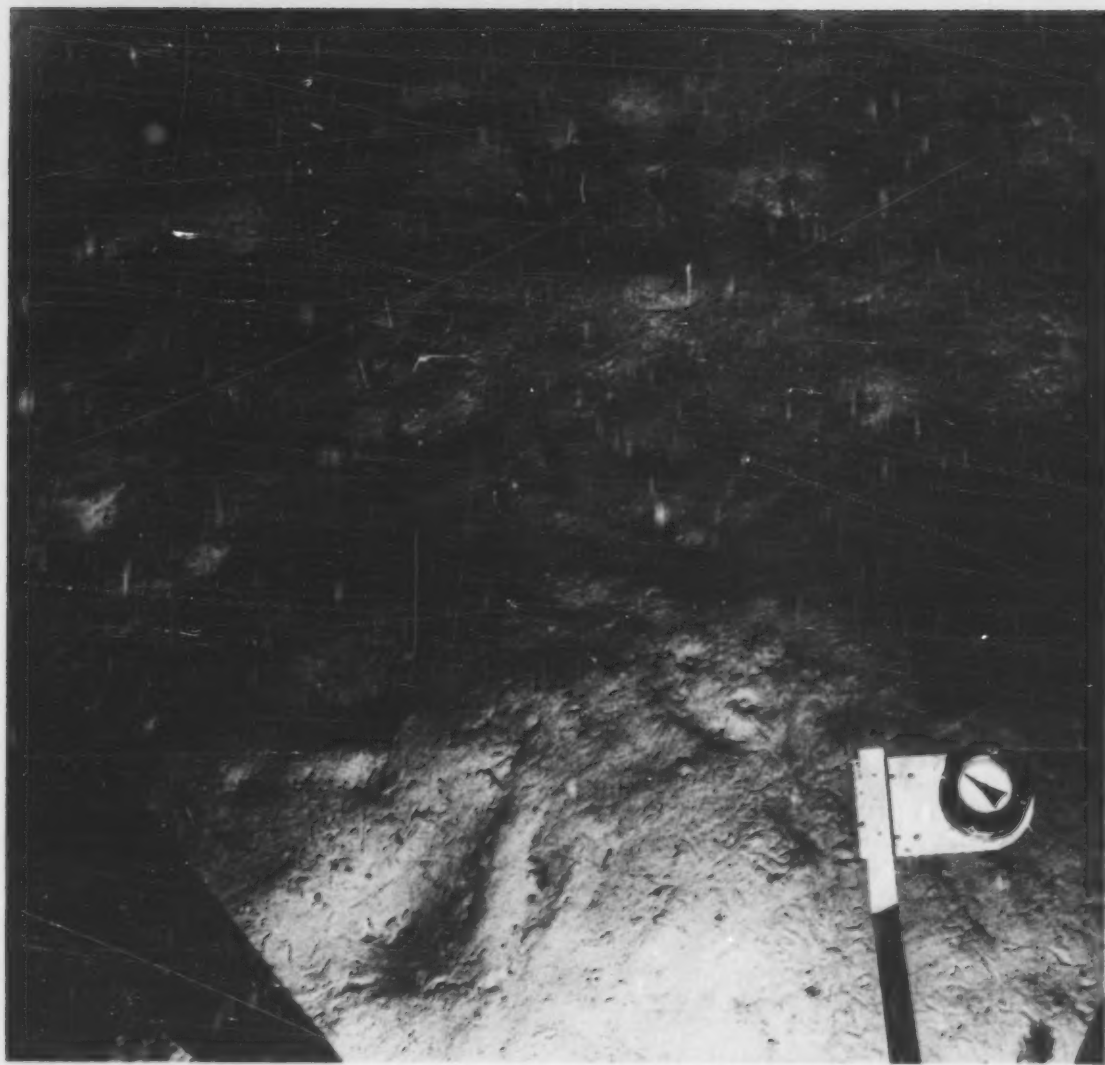


Figure 14.--Pennatulids suggest presence of moderate current at base of continental slope. Camera station K-5; 1224 fathoms; 30°00'N, 72°00'W.

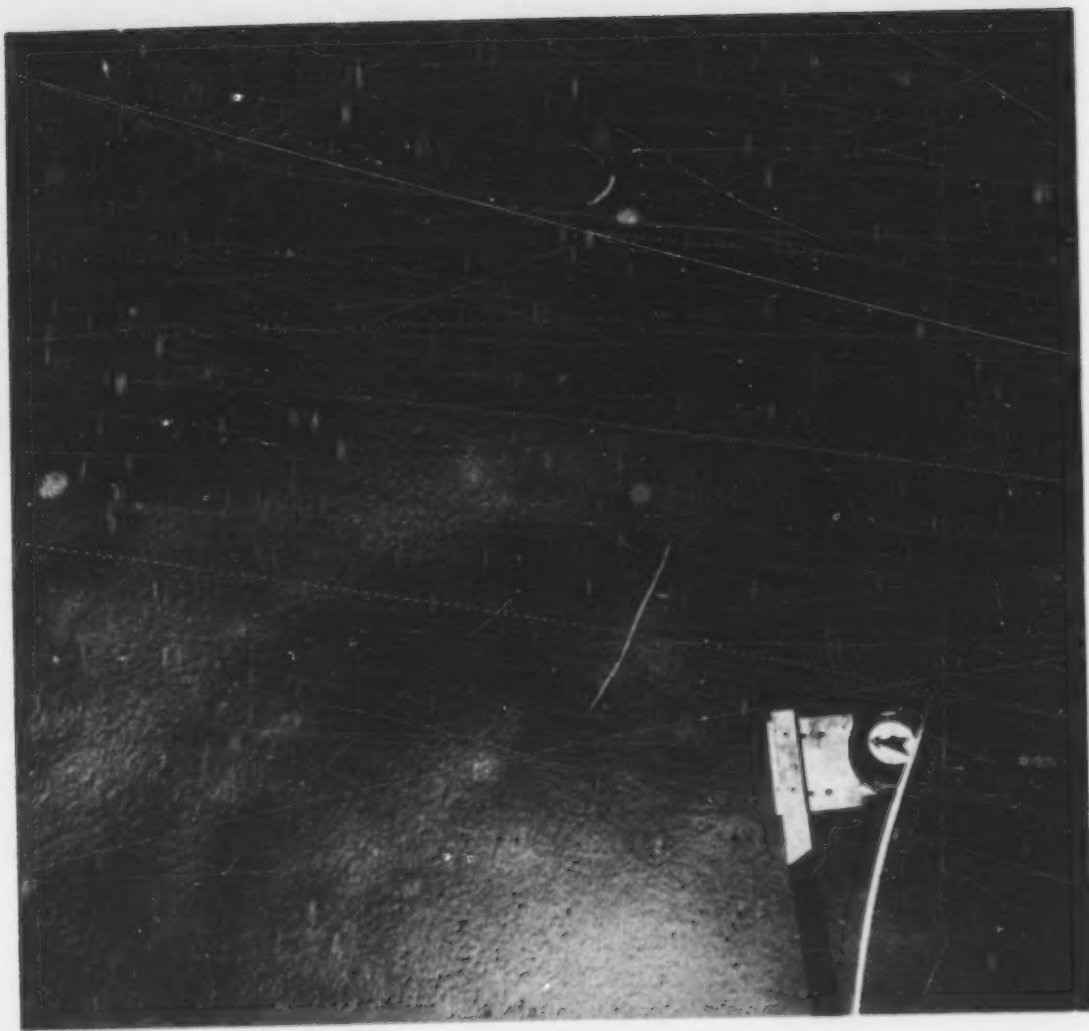


Figure 15.--Echinoids, echinoid tracks, and holothurian feces decorate fine sediment at base of continental slope. Camera station K-6; 1235 fathoms; 80°55'N, 72°07'W.

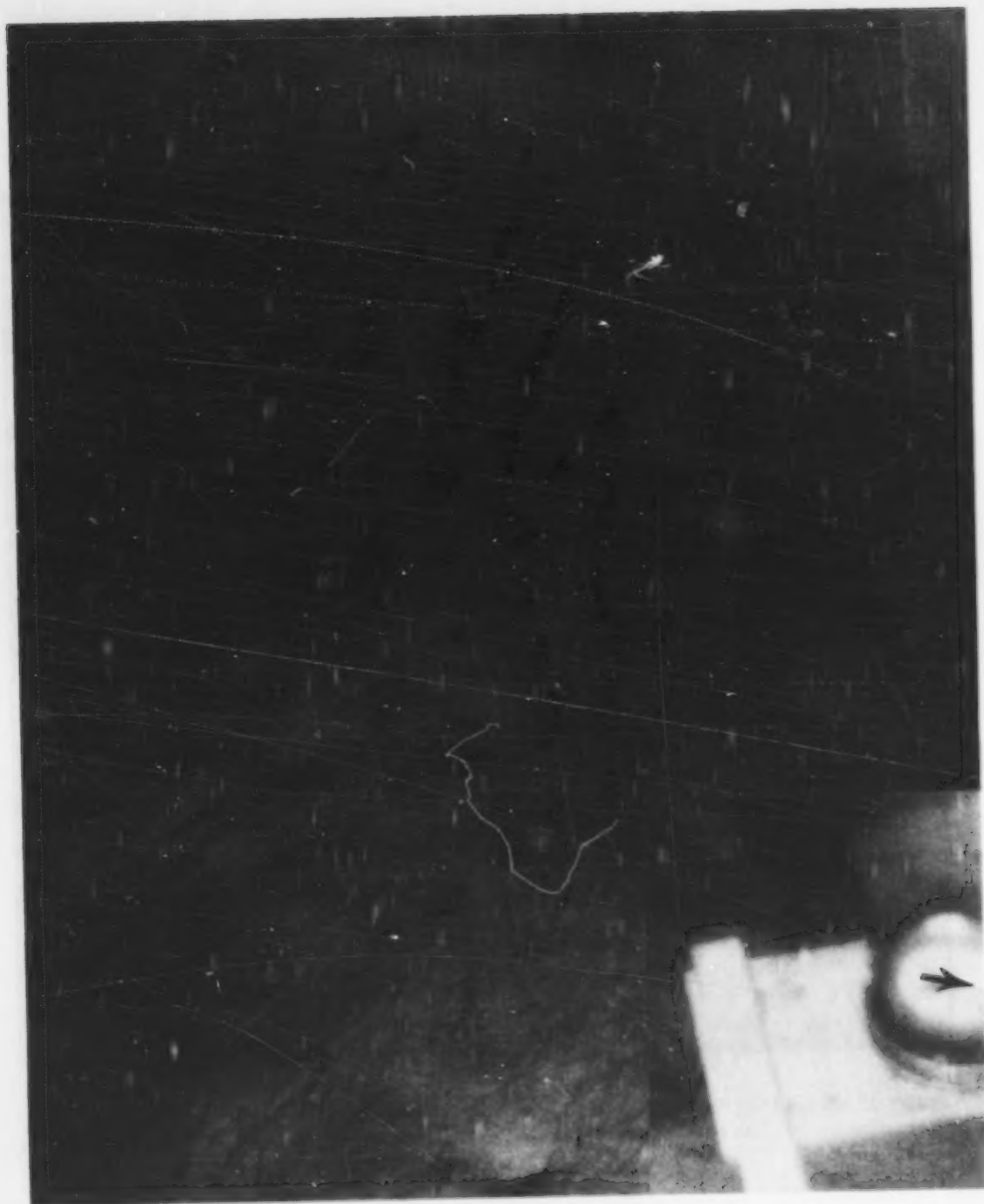


Figure 16.--Fine tracks and trails on fine sediment at base of continental slope. Camera station K-13; 1237 fathoms; $39^{\circ}10'N$, $71^{\circ}46'W$.



Figure 17.--Asteroid, animal volcanos on fine sediment at base of continental rise. Camera station T-4; 1250 fathoms; $38^{\circ}52'N$, $72^{\circ}18'W$.



Figure 18.--Rocks outcrop in slump area at base of continental slope. Camera station K-3; 1318 fathoms; $38^{\circ}50'N$, $72^{\circ}15'W$.



Figure 19.--Slumping and erosion of semiconsolidated sediments at **base of** continental slope. Camera station K-7; 1357 fathoms; 38°45'N, 72°22'W.



Figure 20.--Slump or debris slide at base of continental slope. Camera station K-7; 1357 fathoms; $38^{\circ}45'N$, $72^{\circ}22'W$.

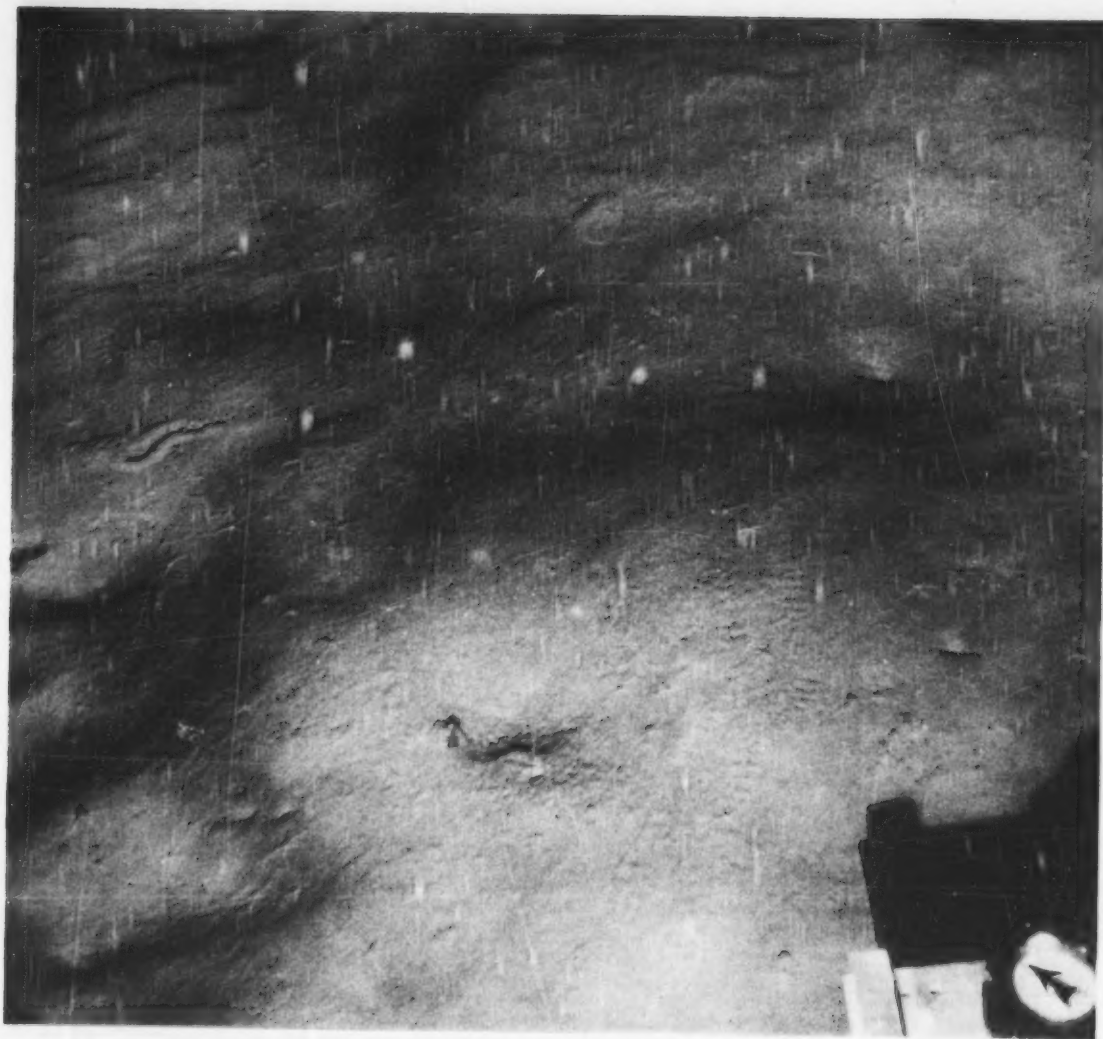


Figure 21.--Slight current-smoothing of upper continental rise near base of continental slope. Camera station K-7; 1357 fathoms; $38^{\circ}45'N$, $72^{\circ}22'W$.



Figure 22.--Filter feeders suggest slight current on upper continental rise near base of continental slope. Camera station K-9; 1424 fathoms; $38^{\circ}40'N$, $71^{\circ}30'W$.



Figure 23.--A common bioturbation pattern on sediment of upper continental rise. Camera station K-8; 1477 fathoms; $38^{\circ}31.5'N$, $74^{\circ}45'W$.



Figure 24.--Close-up view of circular bioturbation of type shown in figure 23.
Camera station K-8; 1477 fathoms; $38^{\circ}31.5'N$, $71^{\circ}45'W$.



Figure 25.--Circular bioturbations on upper continental rise. Upper: Camera station T-5; 1457 fathoms; $38^{\circ}39.2'N$, $72^{\circ}02'W$. Center and Lower: T-6; 1490 fms; $38^{\circ}30'N$, $72^{\circ}07'W$.



Figure 26.--Circular bioturbation in middle section of upper continental rise.
 Upper: Camera station T-7; 1515 fathoms; $38^{\circ}26.4'N$, $72^{\circ}02'W$.
 Lower: T-8; 1530 fms; $38^{\circ}20'N$, $71^{\circ}50.5'W$.



Figure 27.--Radial bioturbations in soft sediment on tranquil bottom of upper continental rise. Upper: Camera station T-9; 1600 fathoms; $38^{\circ}08.5'N$, $71^{\circ}40'W$. Lower: T-10; 1653 fms; $38^{\circ}02.5'N$, $71^{\circ}34.6'W$.



Figure 28.--Radial and circular bioturbations on smooth (possibly smoothed) soft sediment of upper continental rise. Camera station RC-11-195; 1645 fathoms; 38°20'N, 71°00'W.



Figure 29.--Current-smoothed sediment near outer margin of upper continental rise. Camera station RC-137; 1690 fathoms; 37°00'N, 72°32'W.



Figure 30.--Filter feeders and sediment smoothing indicate increased current effects at base of upper continental rise. Upper: Camera station T-11; 1800 fathoms; $37^{\circ}52'N$, $71^{\circ}12'W$. Lower: T-12; 1897 fms; $37^{\circ}40.5'N$, $71^{\circ}12'W$.

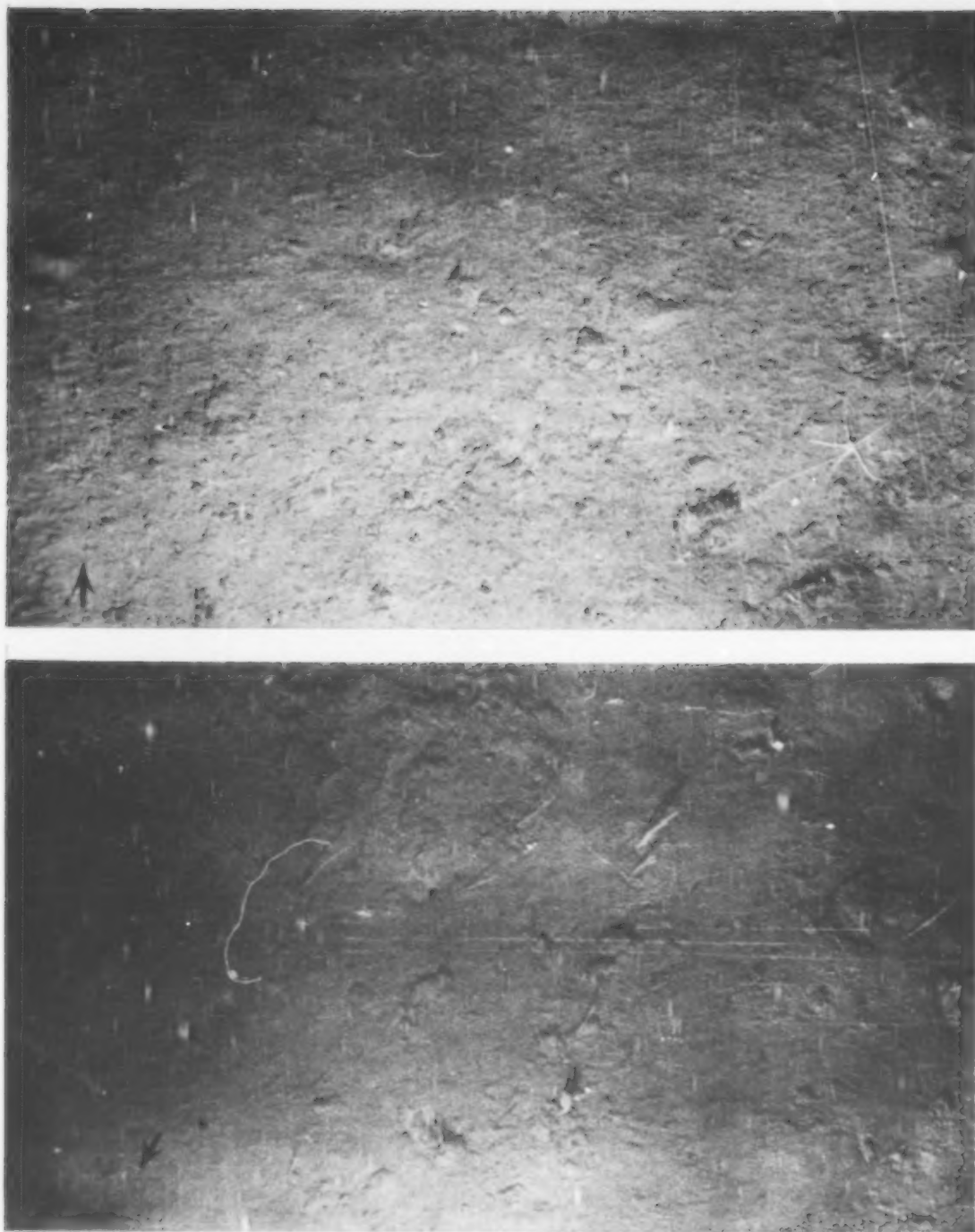


Figure 31.--Current scour and small sediment drifts in lee of bioturbations produced by southwesterly flow of Western Atlantic Undercurrent. Upper and Lower: Camera station T-13; 2105 fathoms; 37°35.8'N, 71°05'W.



Figure 32.--Filter feeders and eroded semiconsolidated sediment increased current activity at transition between upper and lower continental rise.
Upper and Lower: Camera station RC-10-290; 1835 fathoms; 37°31'N, 72°15'W.



Figure 33.--Sediment smoothing beneath the Western Atlantic Undercurrent on lower continental rise. Upper and Lower: Camera station T-14; 2185 fathoms; 37°21'N, 70°59'W.

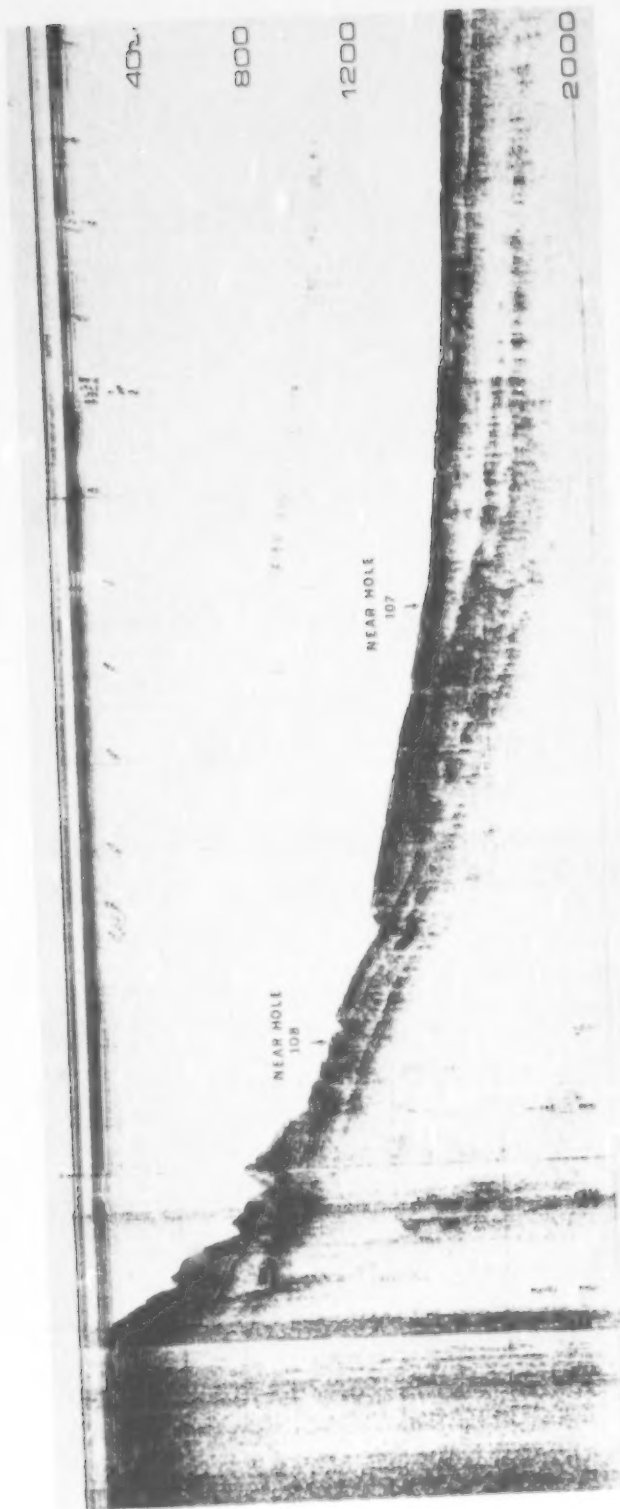


Figure 35.--Seismic reflection profile and Deep-Sea Drilling Project sites 107 and 108. At Site 107, on the smooth surface of the upper continental rise, only Pleistocene sediments were encountered. At Site 108, in the dissected area at the base of the continental slope, Miocene hemipelagic sediments were encountered at the sea floor. Recent and Pleistocene deposits had been removed and were not present at Site 108.

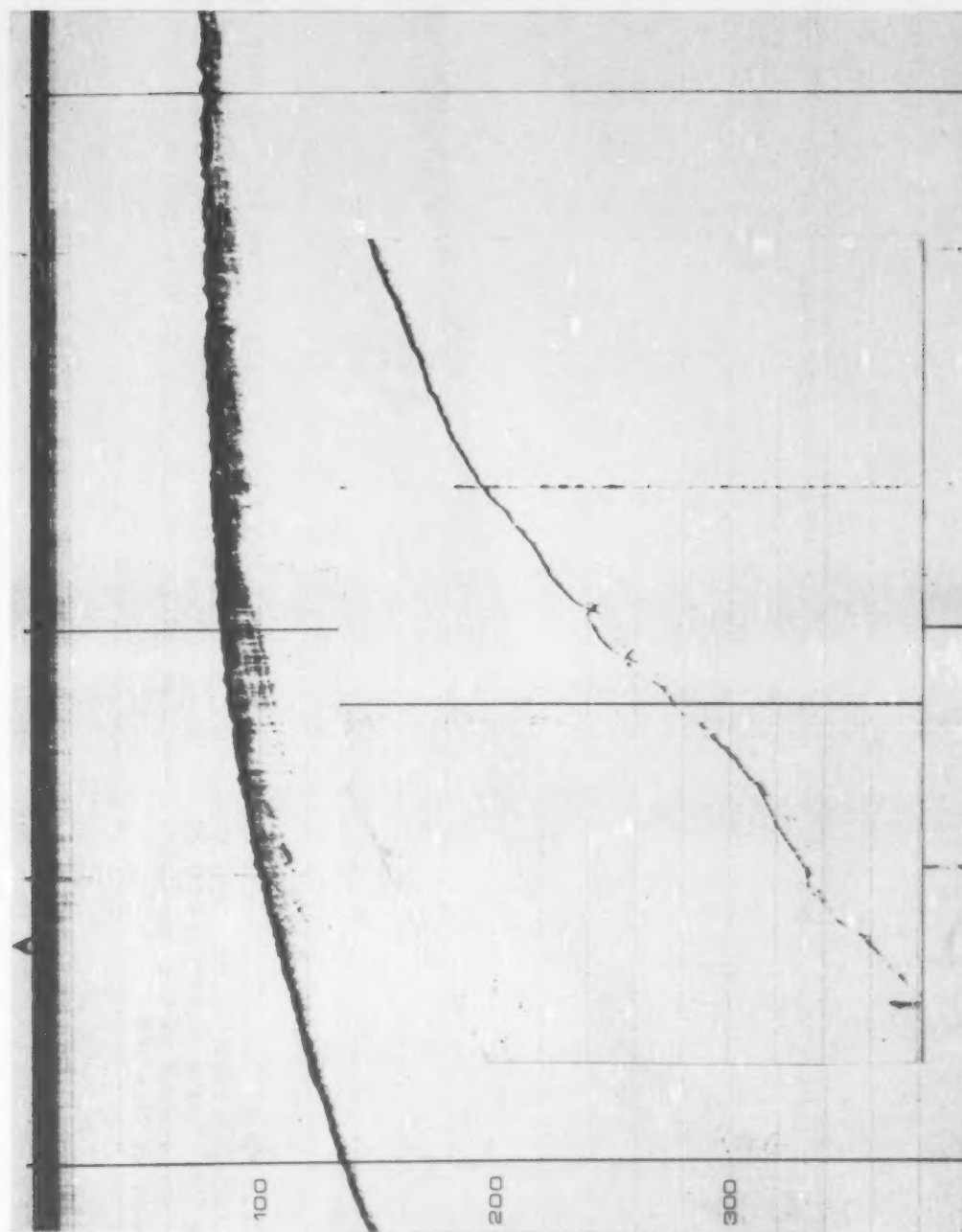


Figure 36-1.--Echogram from 3.5-kH echo sounder during Vema cruise 30 reveals stratification of uppermost seafloor sediments. Sediments of upper continental slope are beveled at shelf break.

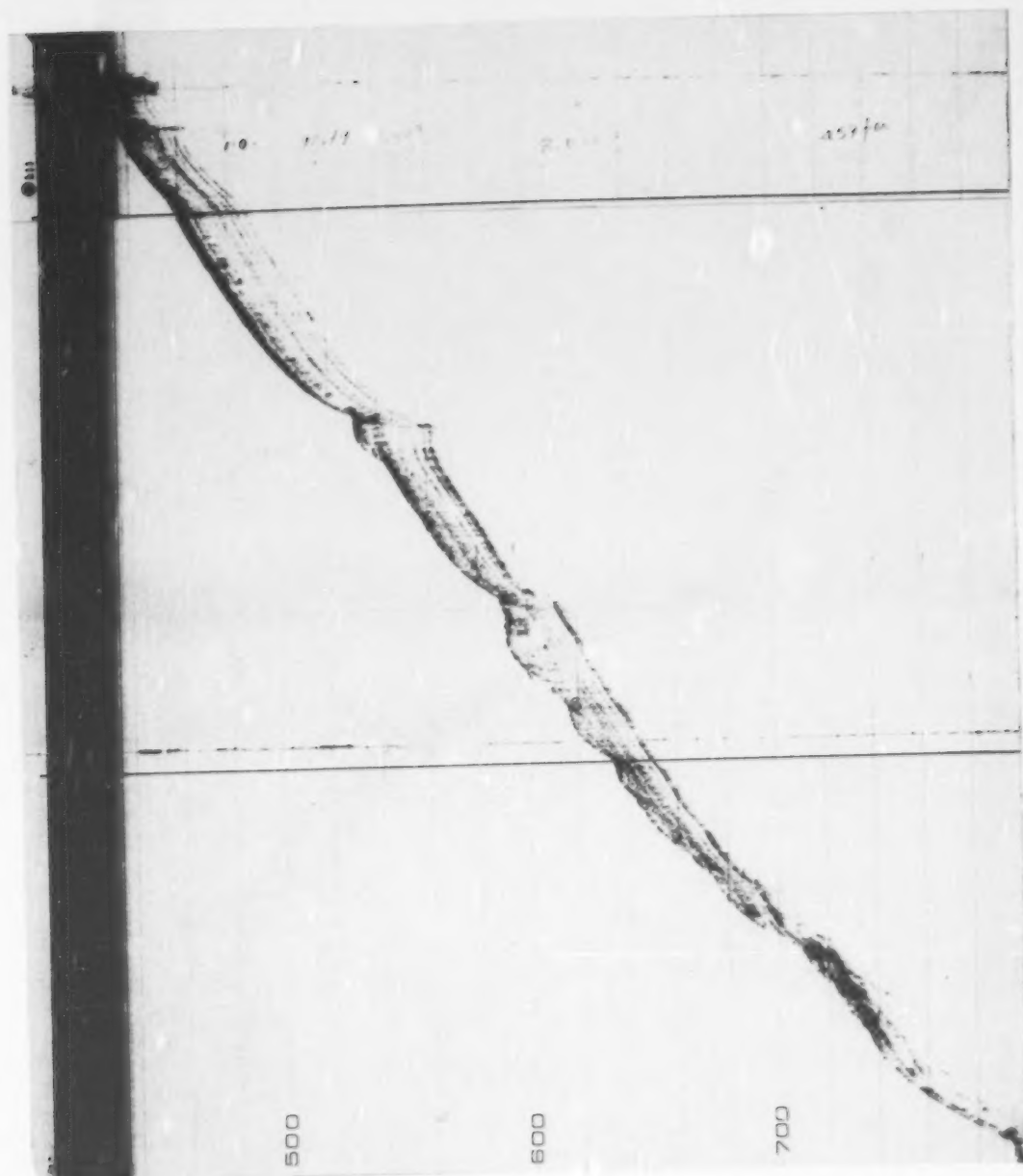


Figure 36-2.--Thin sediments of upper continental slope are increasingly dissected downslope.

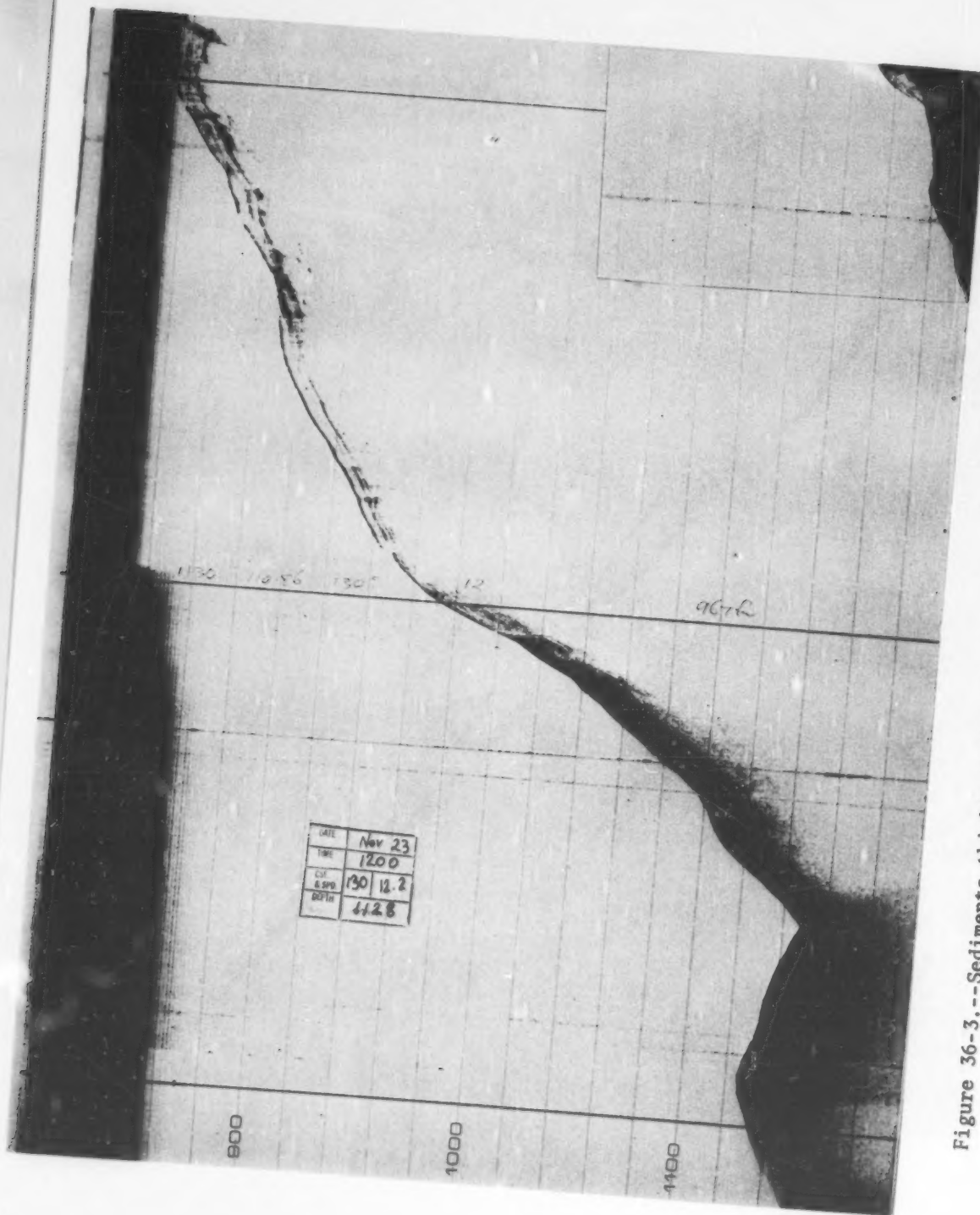


Figure 36-3.--Sediments thicken in irregular manner near base of continental slope.

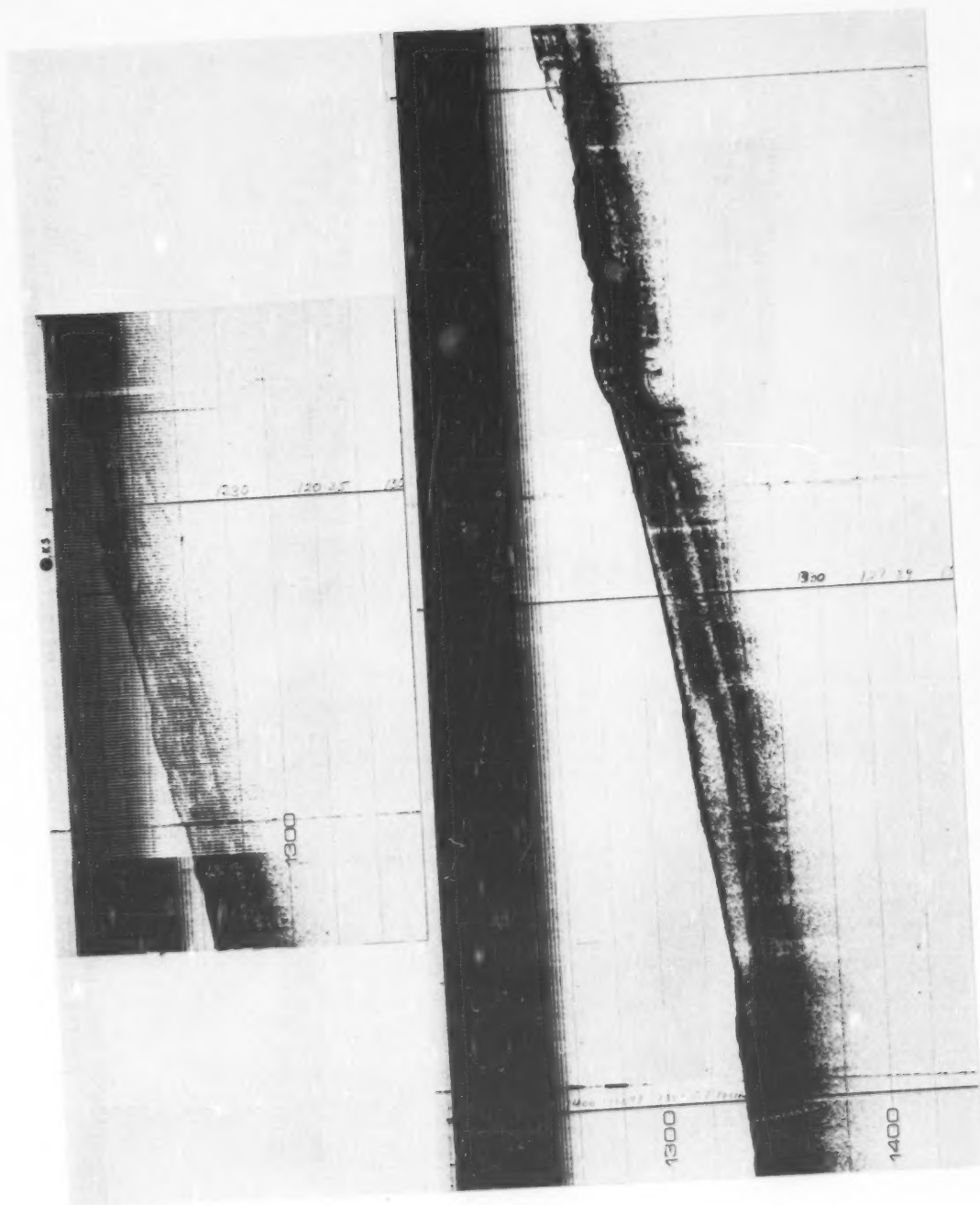


Figure 36-4.--Near base of continental slope, on inner edge of upper continental rise, sediment is dissected and shows patterns of hyperbolae associated with bedforms.

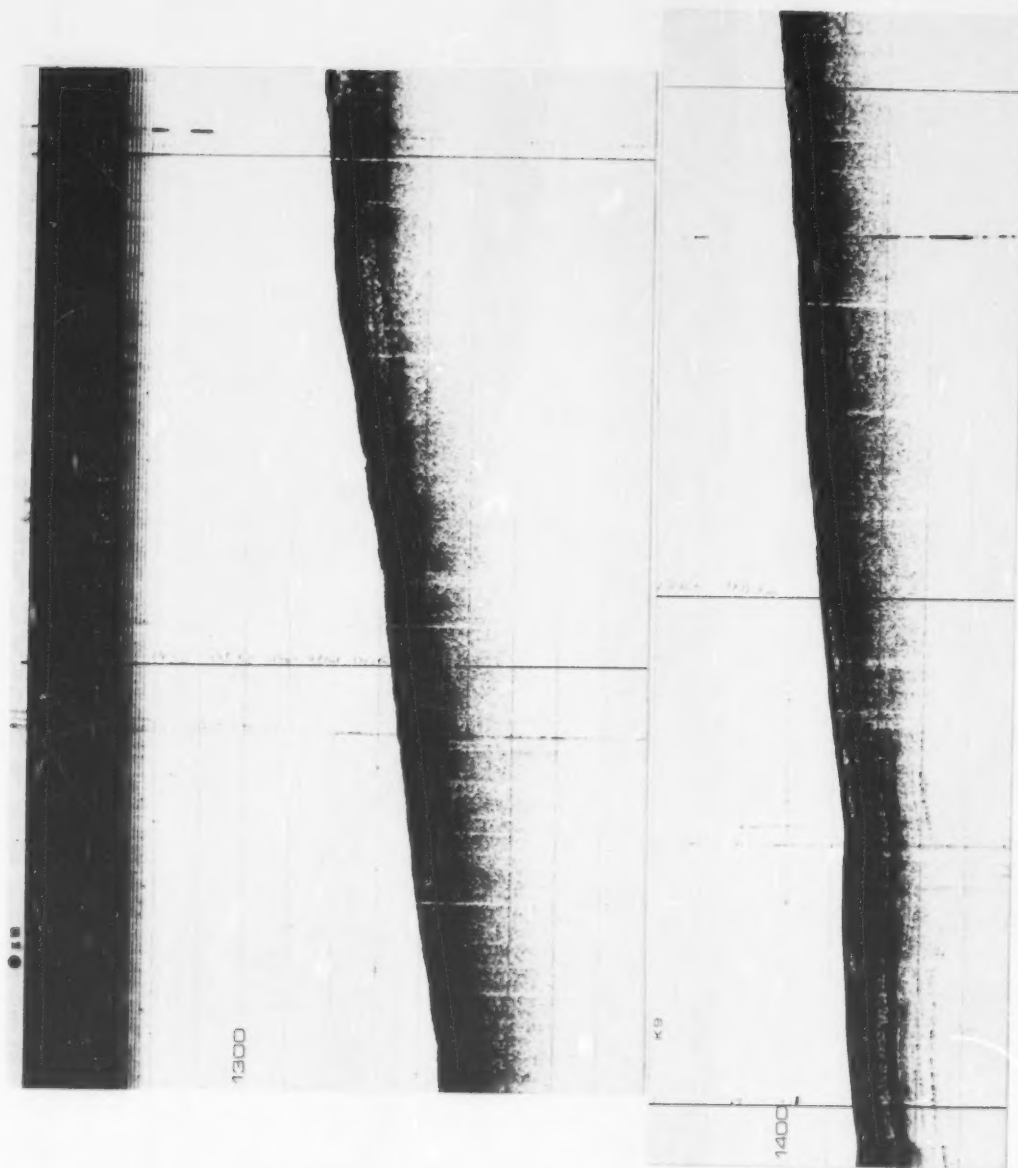


Figure 36-5.--Upper continental rise is largely covered by stratified sediments. Occasionally (upper profile) hyperbolae suggest the effects of current bottom processes.

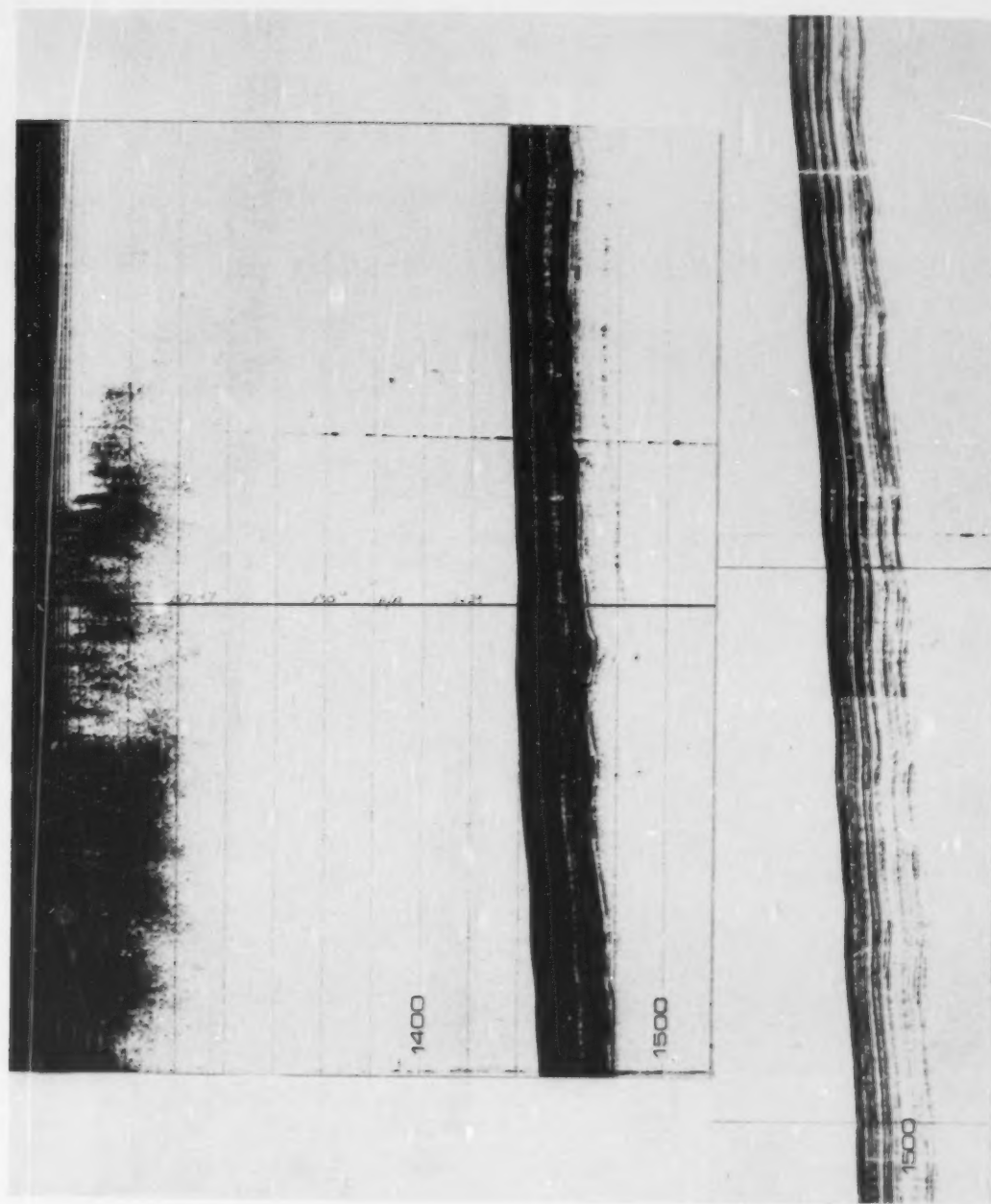


Figure 36-6.--Perfectly stratified sediments in tranquil midportion of upper continental rise.

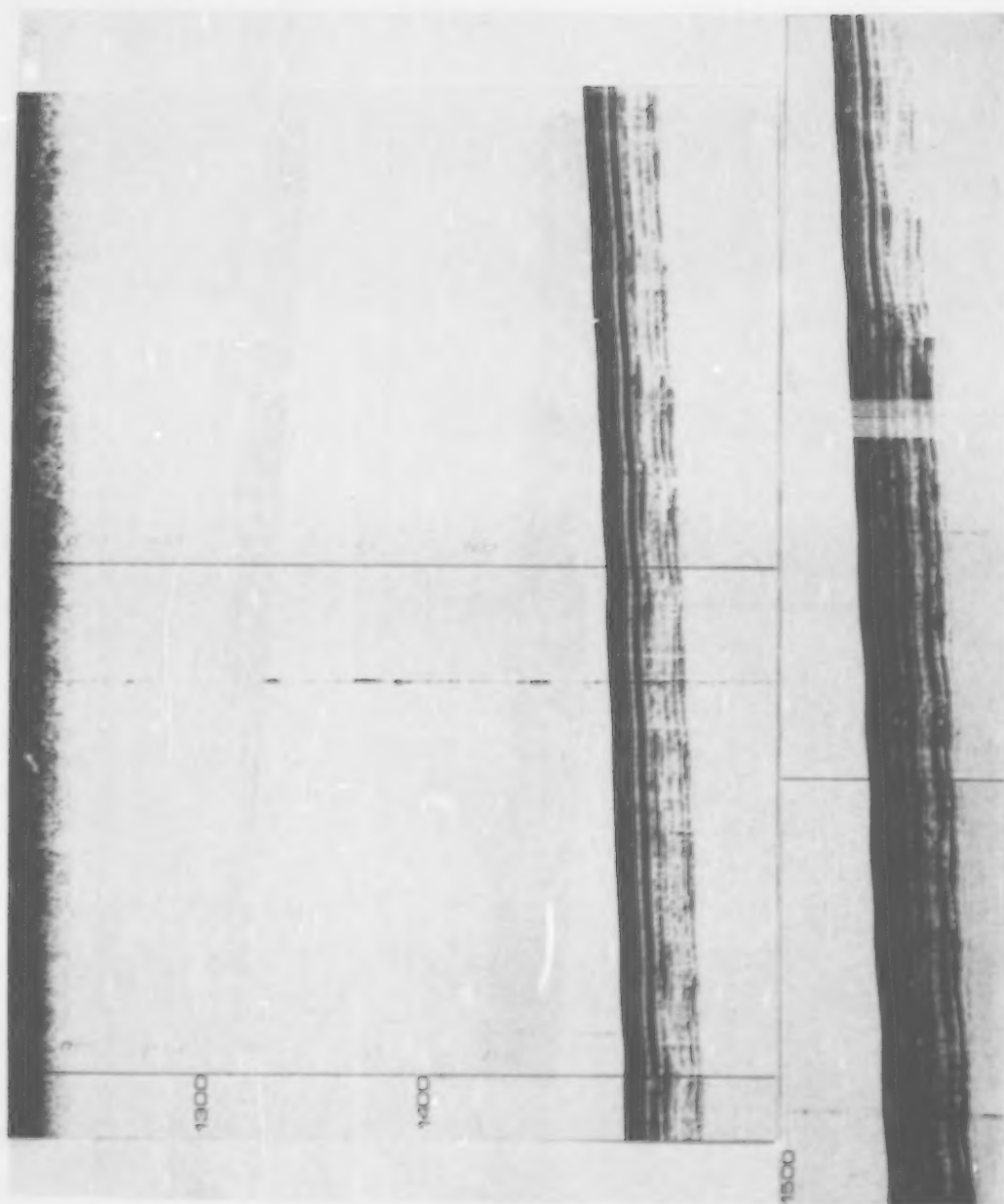


Figure 3o-7.--Upper continental rise.

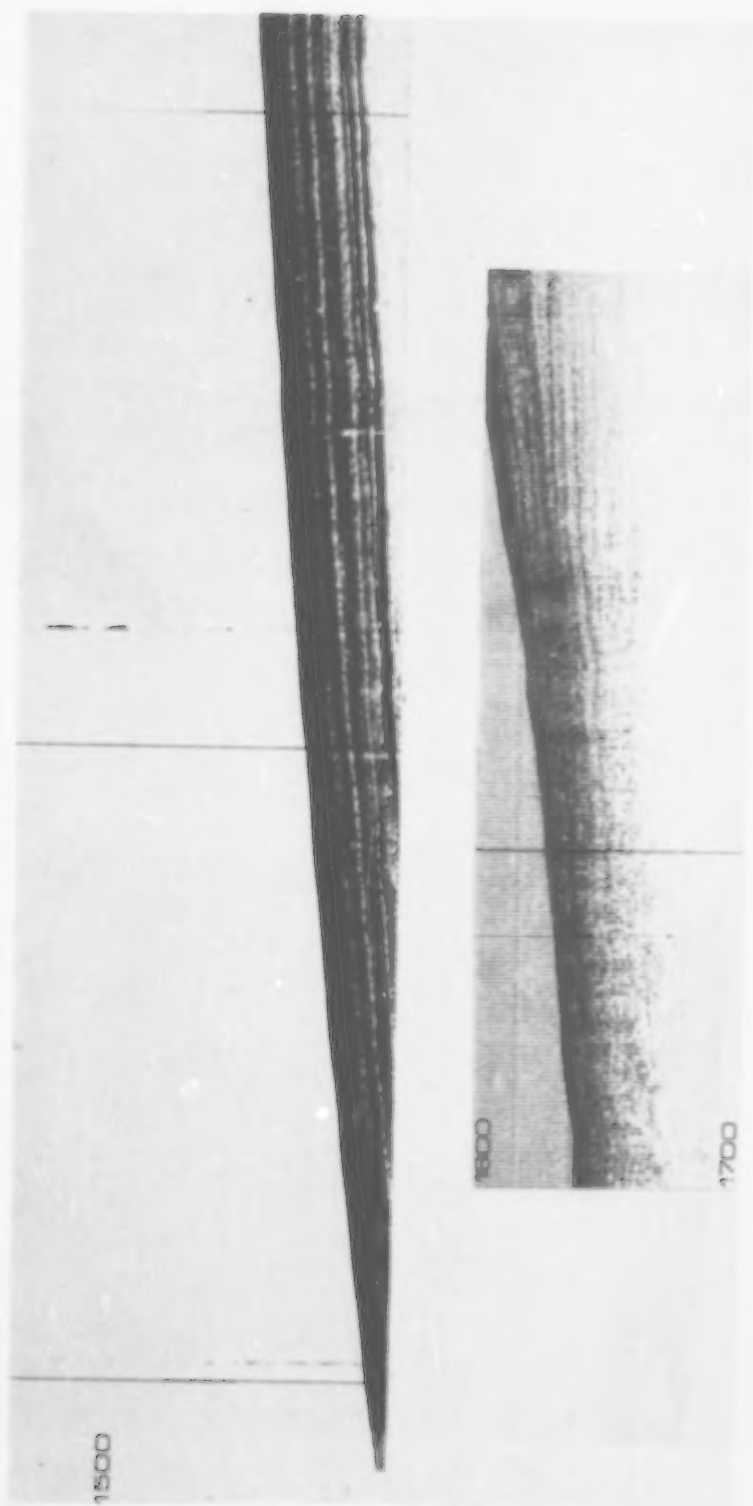


Figure 36-8.--Stratified sediments blanket upper continental rise.

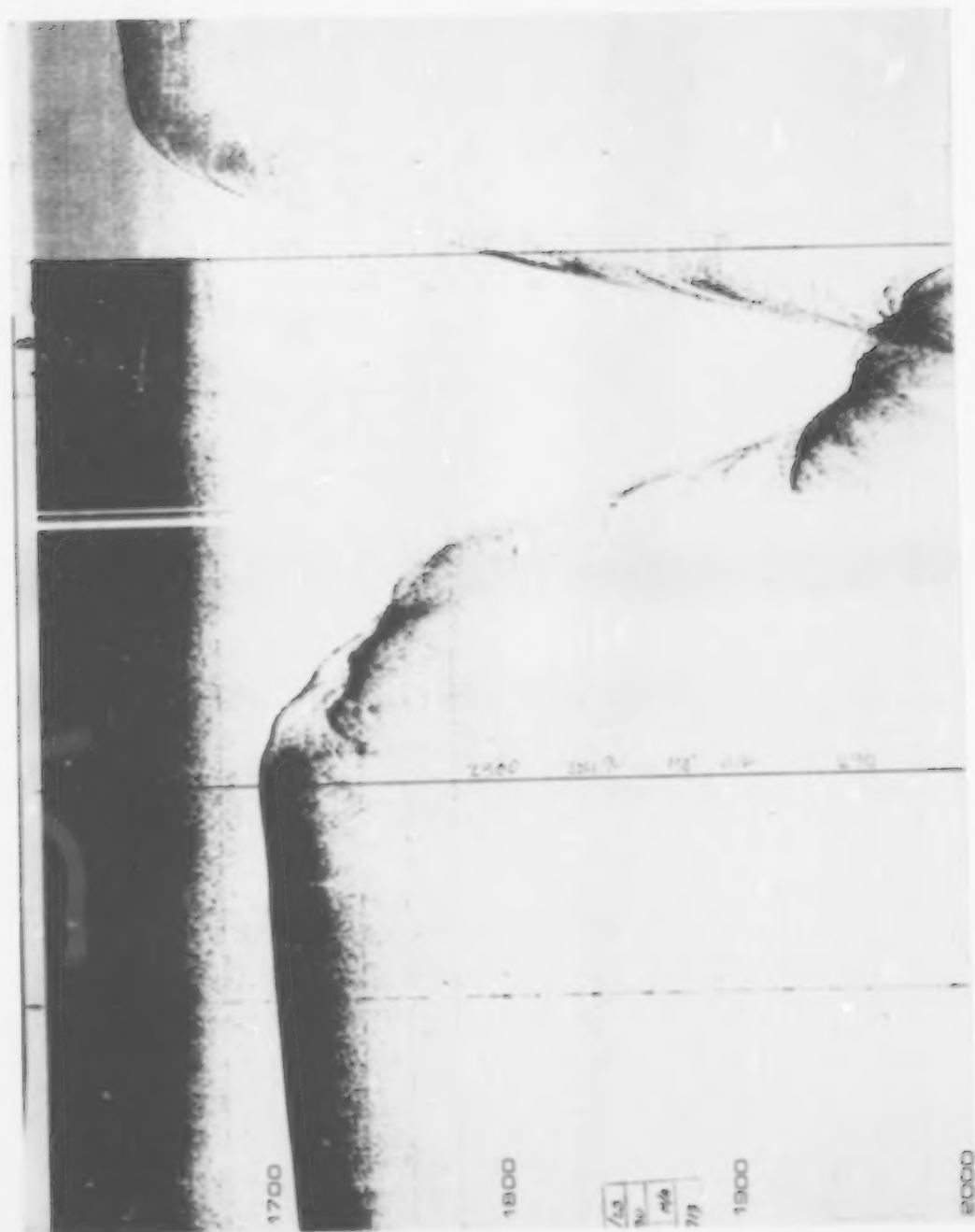


Figure 36-9.--Stratified sediments of upper continental rise are deeply dissected by Hudson Canyon. A beveling of uppermost beds is observed within a few miles of the canyon rim.

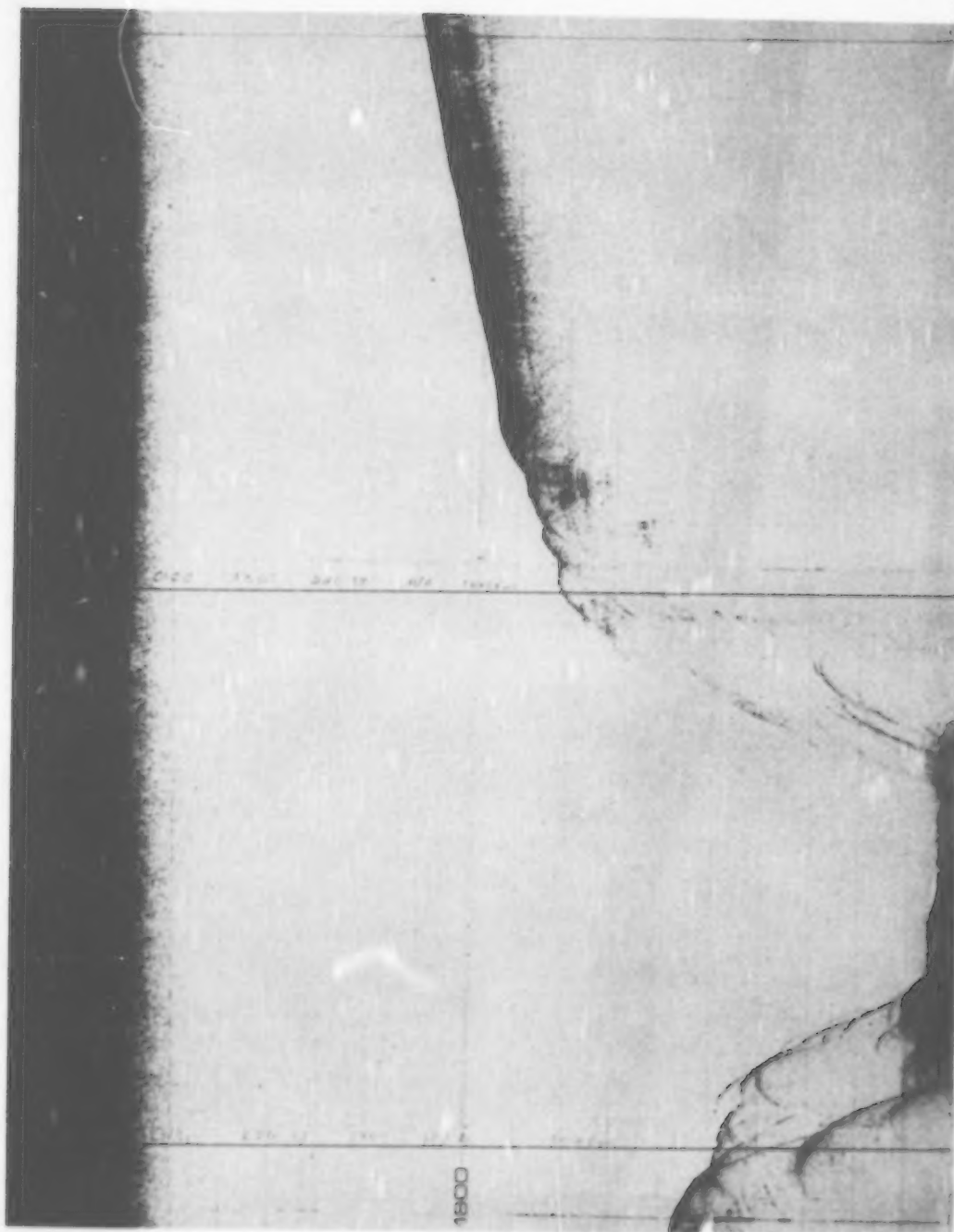


Figure 36-11.--Eastern branch of Hudson Canyon presents smaller pattern of dissection and beveling at canyon rim.

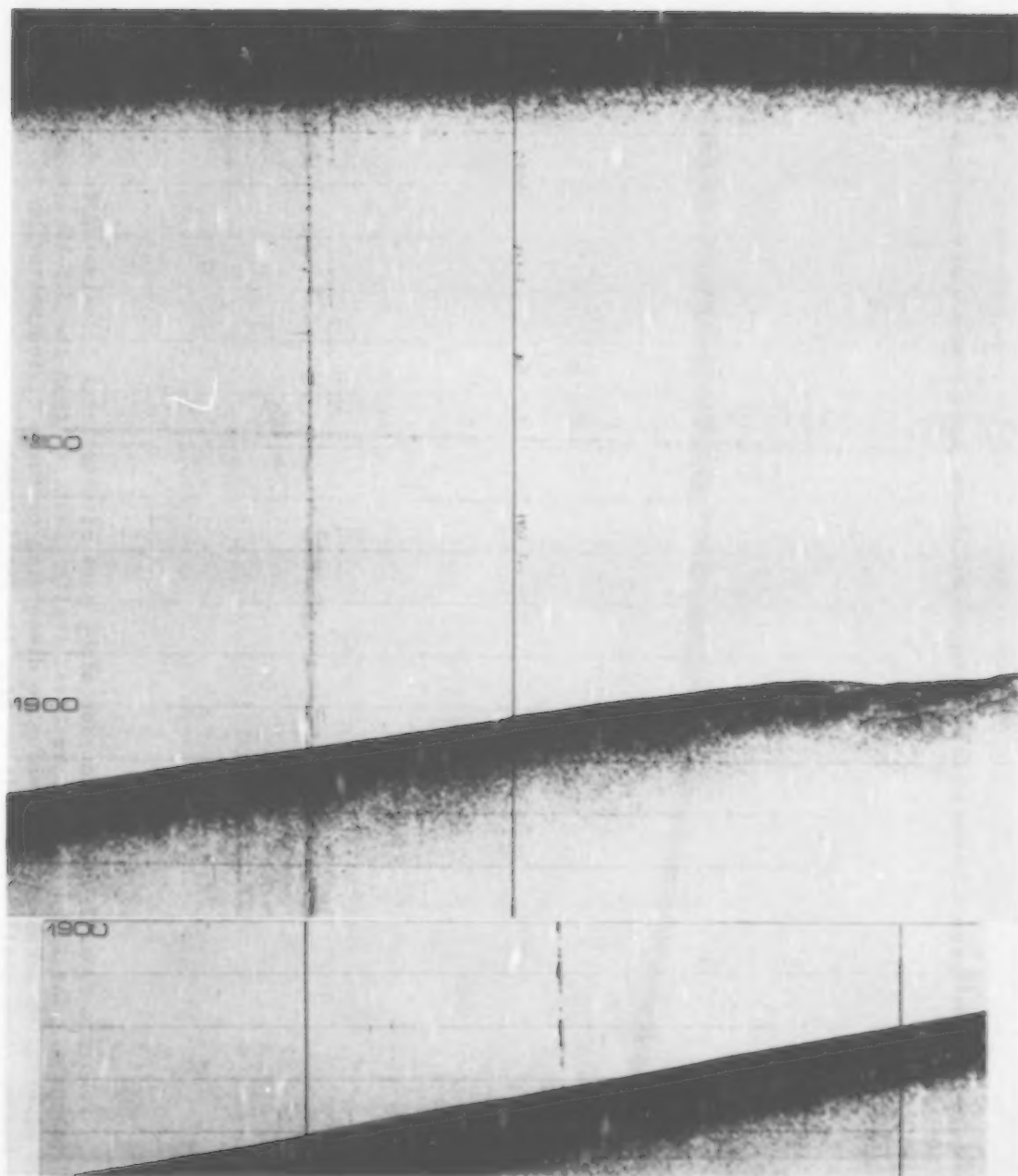


Figure 36-12.--Small-scale beveling on east rim of east branch of Hudson Canyon gives way to even-bedded deposits of a tranquil environment of sedimentation.

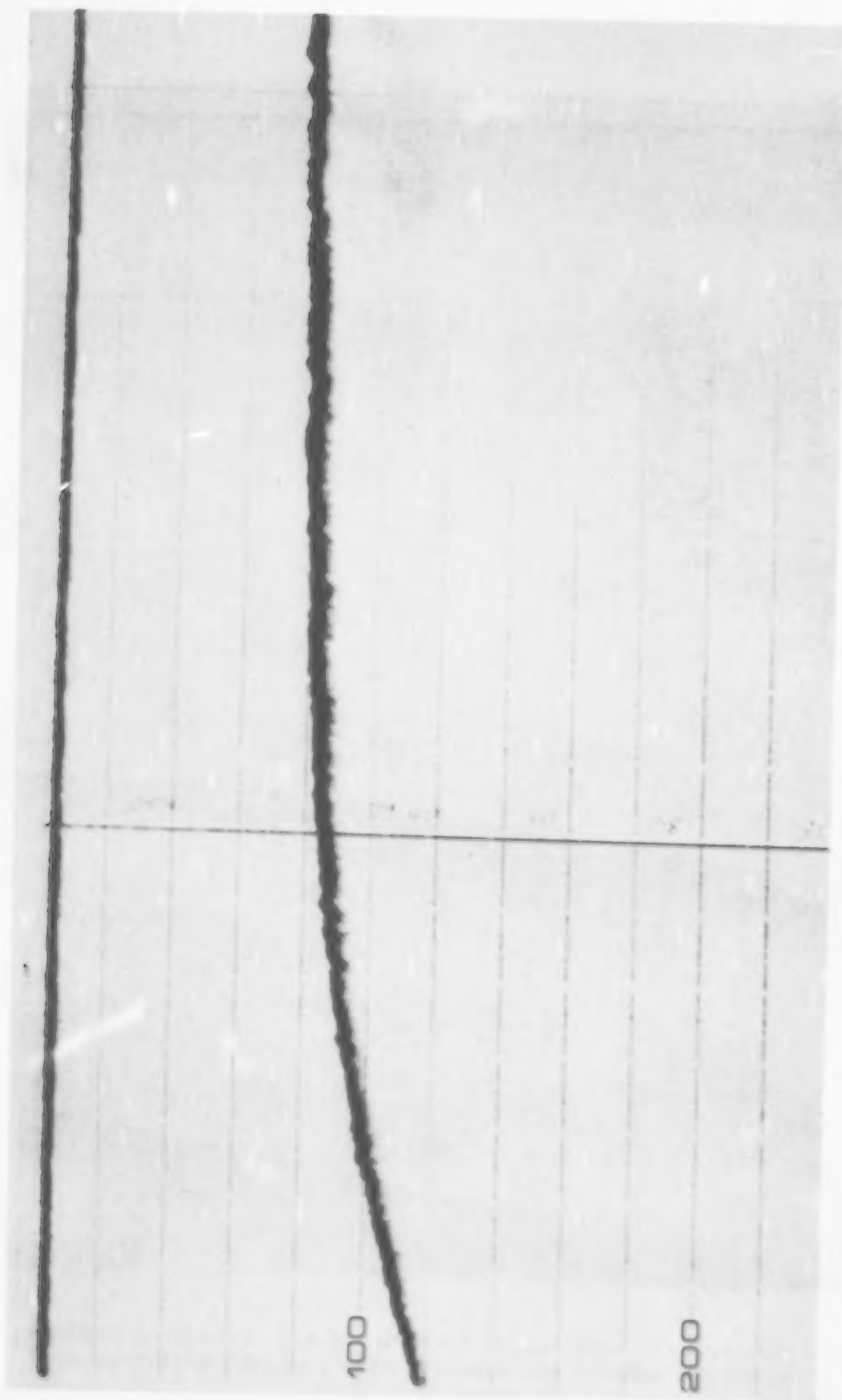


Figure 37-1.--Echogram from 12-kH echo sounder along part of same track illustrated in figure 36 for 3.5-kH echogram. The 12-kH echogram resolves smaller features than the 3.5-kH echogram, but its limited penetration makes it less useful in discerning patterns of sedimentation and bottom activity. This echogram shows small irregularities near the shelf break.

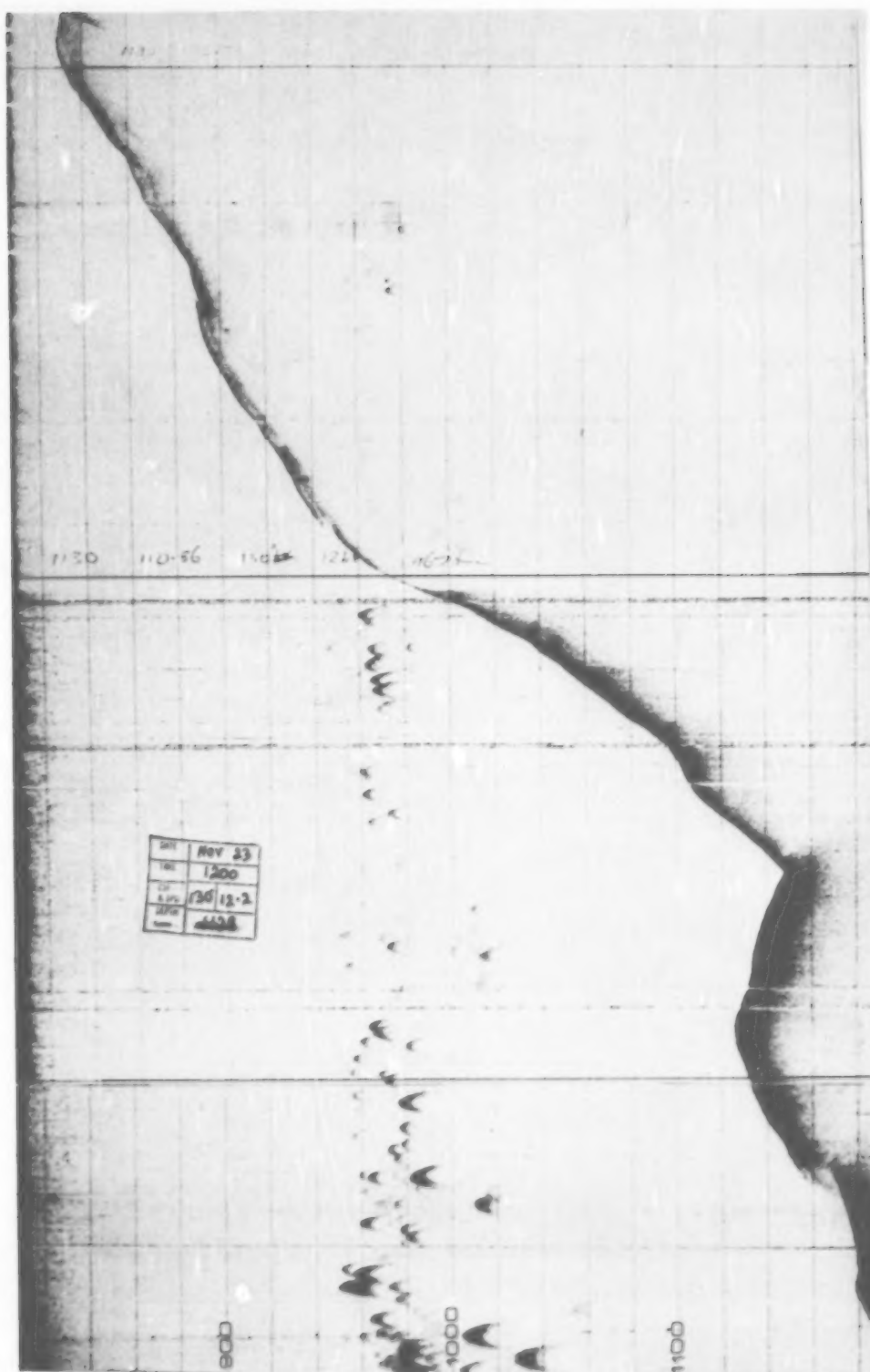


Figure 37-2.--Lower continental slope.

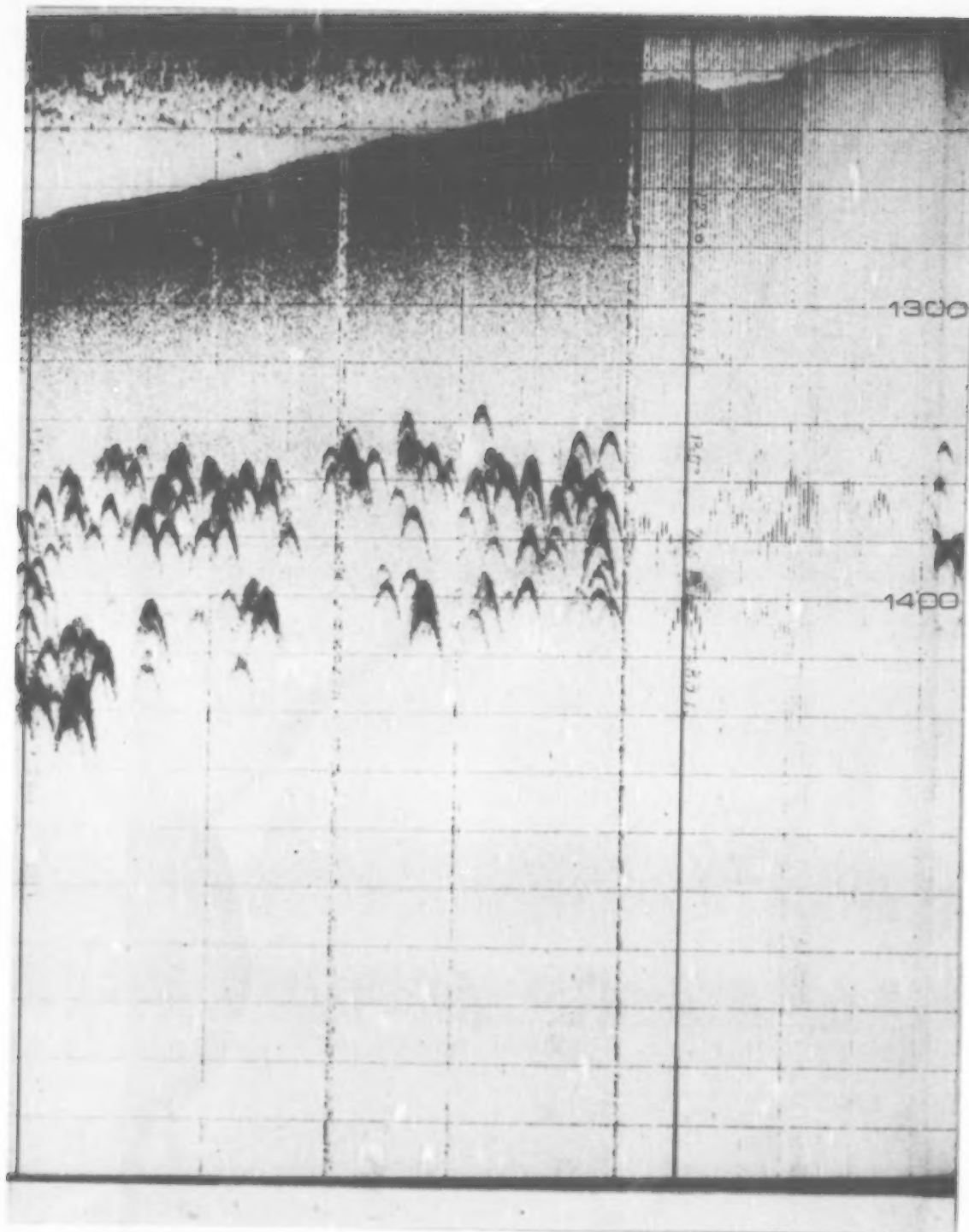


Figure 37-3.--Upper continental rise.

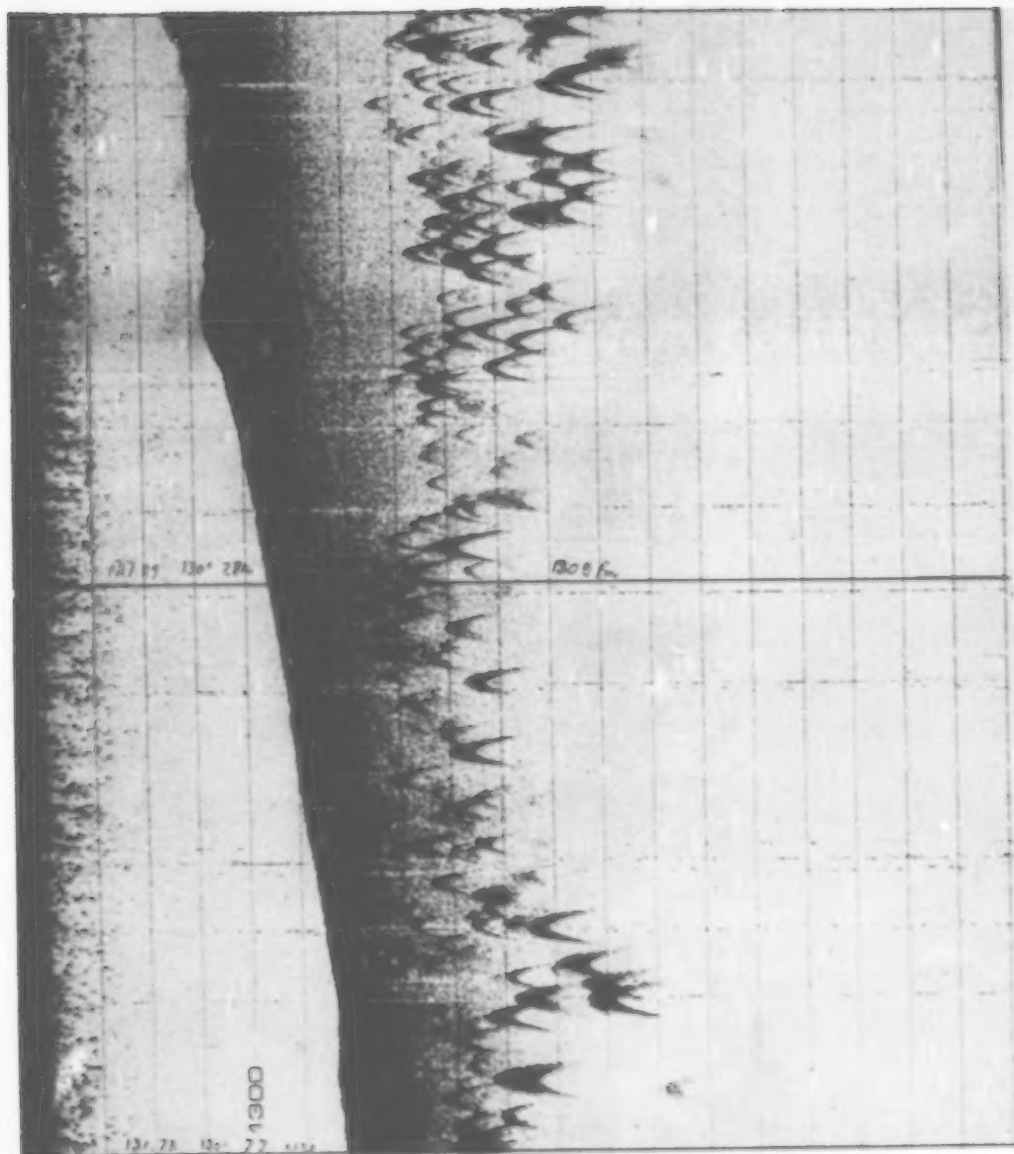


Figure 37-4.--Area of small-scale dissection near base of continental slope on inner margin of upper continental rise. Prominent hyperbolae are from scattering layer as recorded on 0-400 fathom scale.

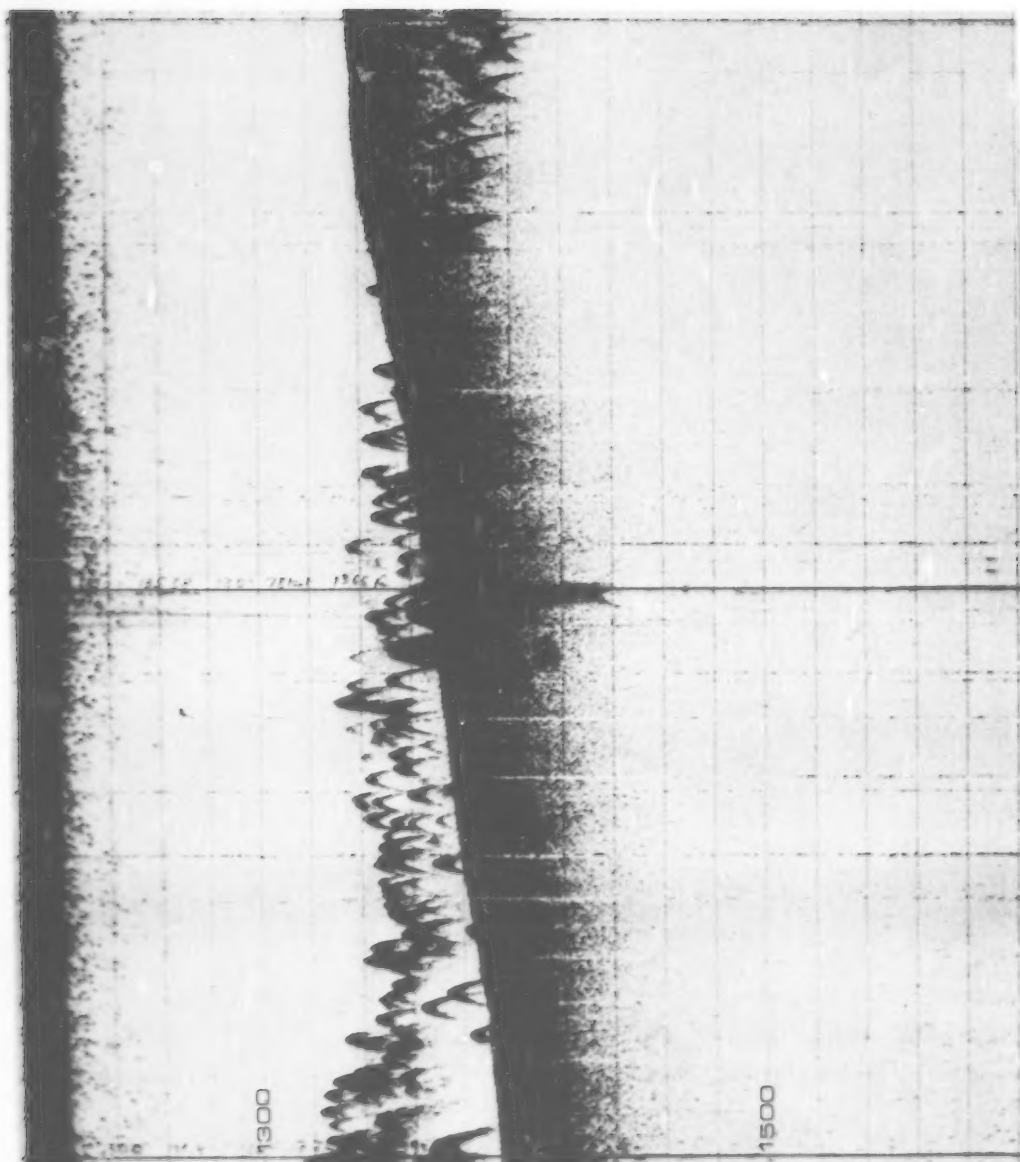


Figure 37-5.--Upper continental rise.

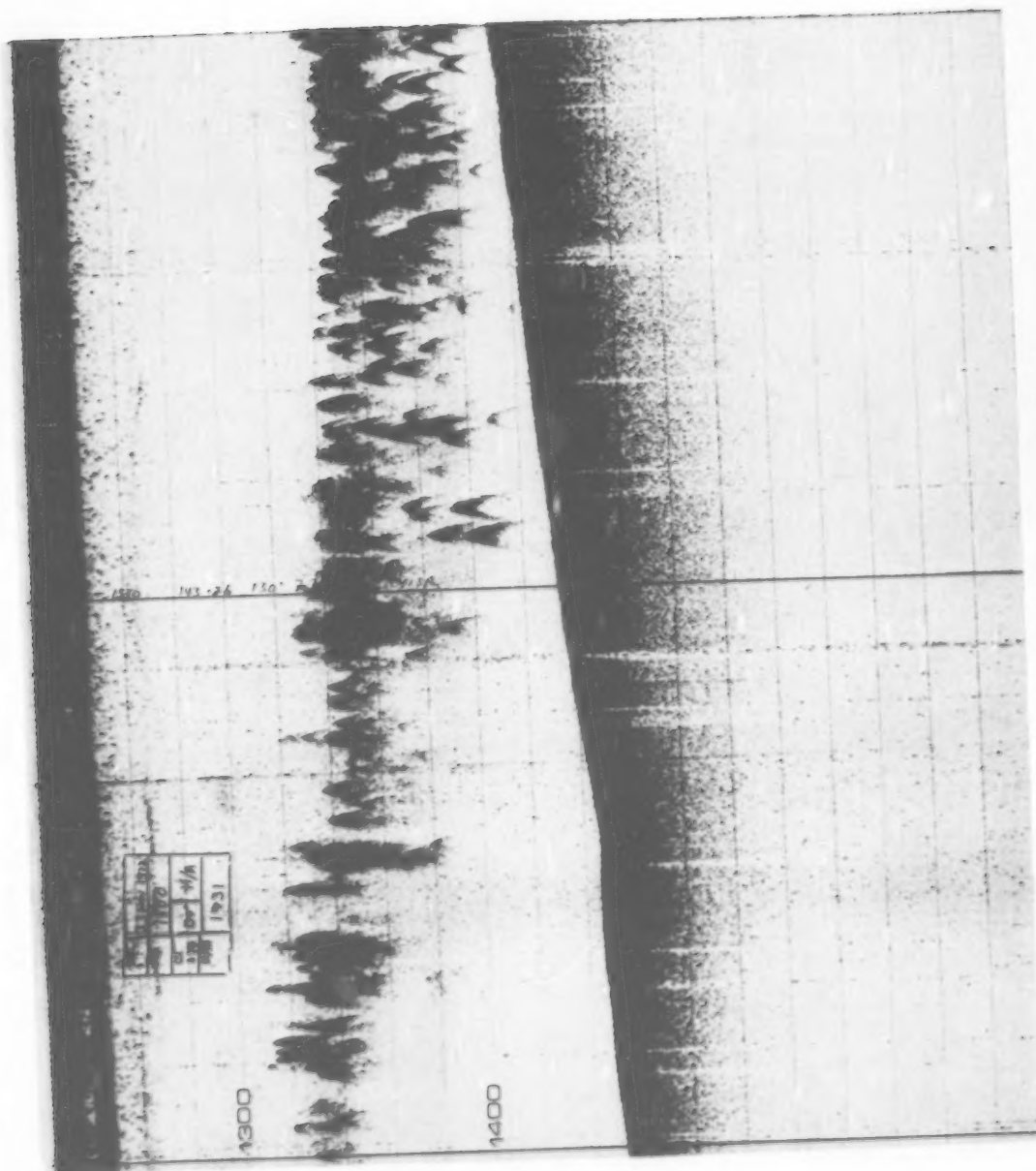


Figure 37-6.--Upper continental rise.

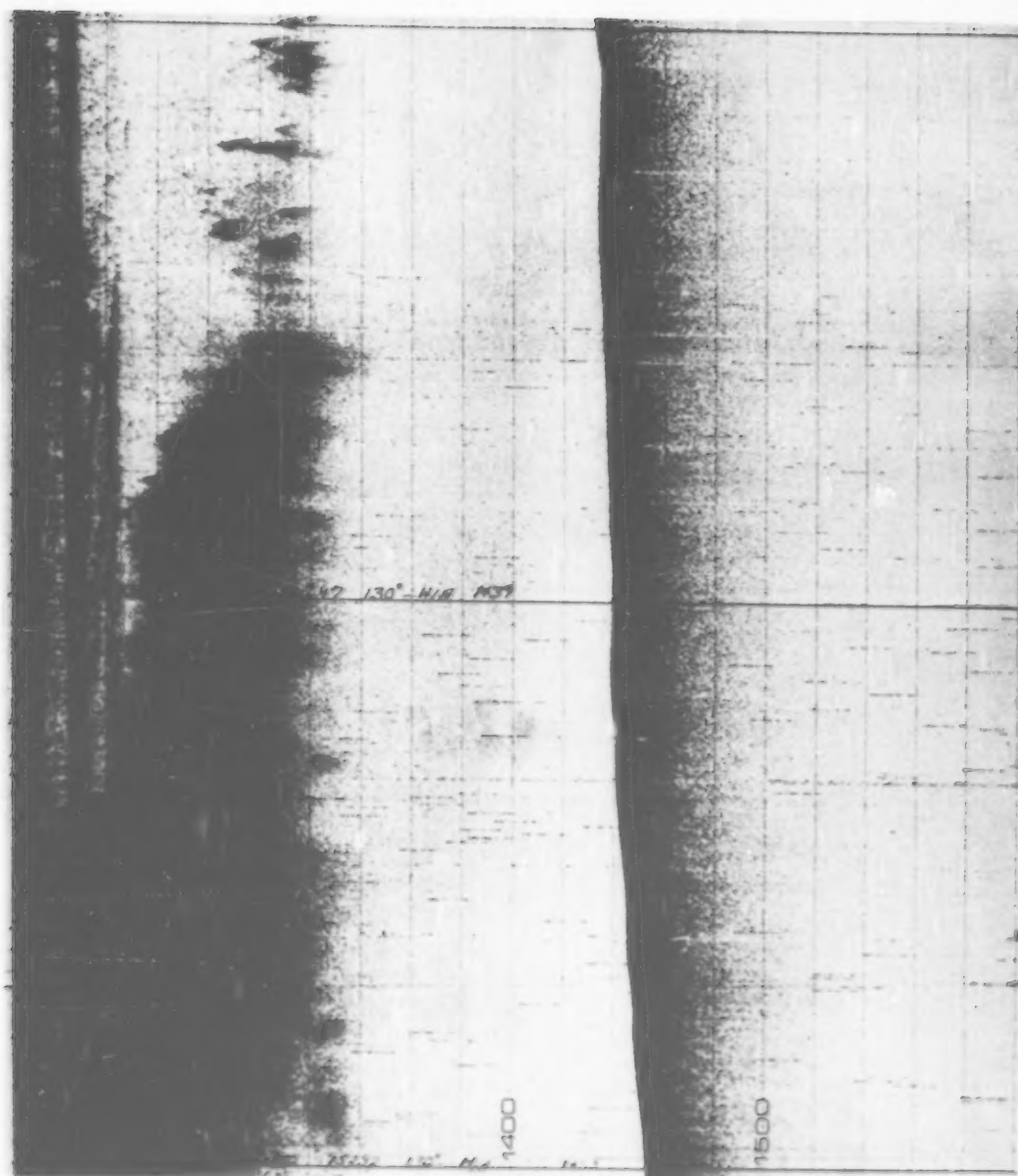


Figure 37-7.--Smooth bottom of upper continental rise.

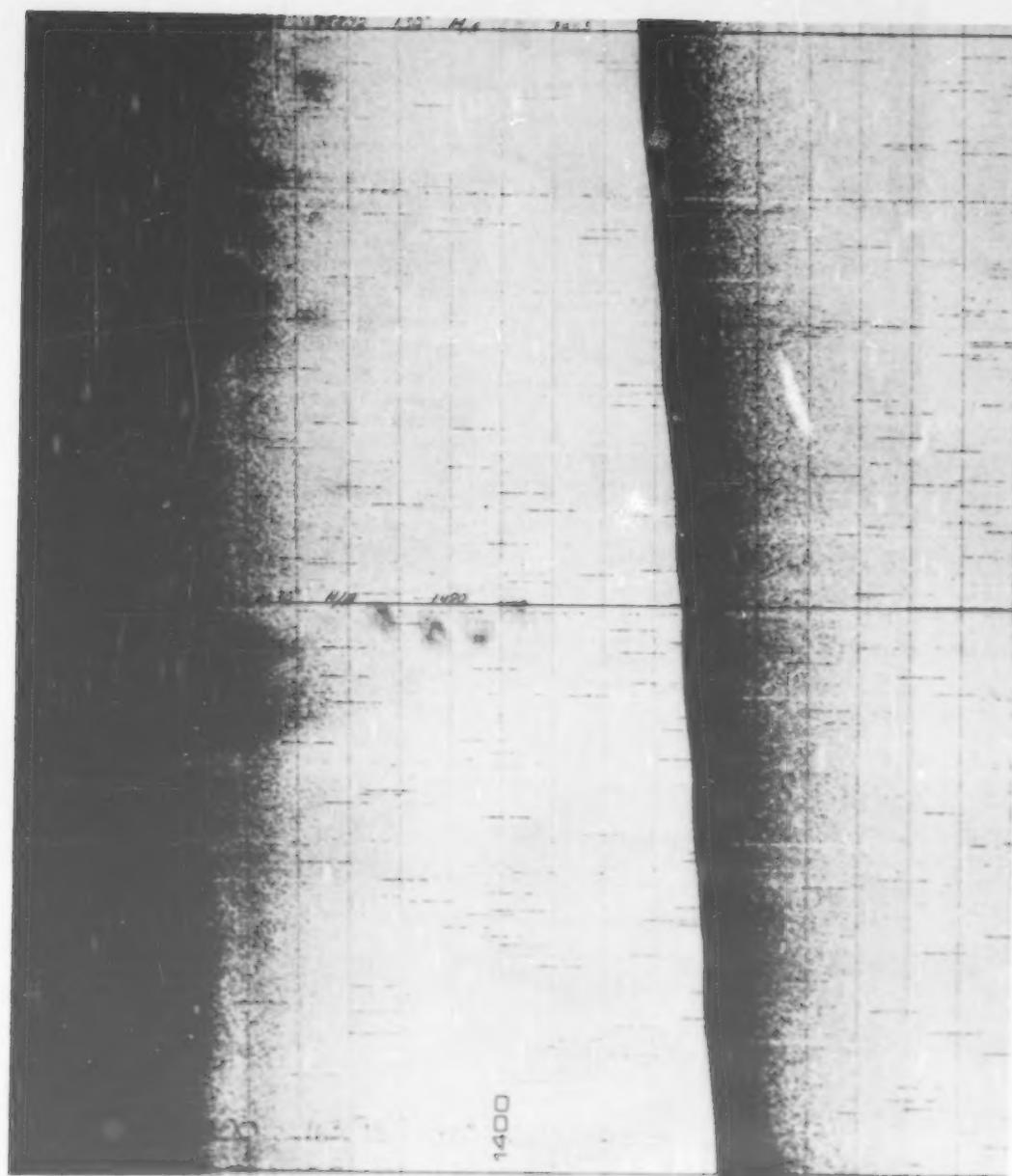


Figure 37-8.--Upper continental rise.

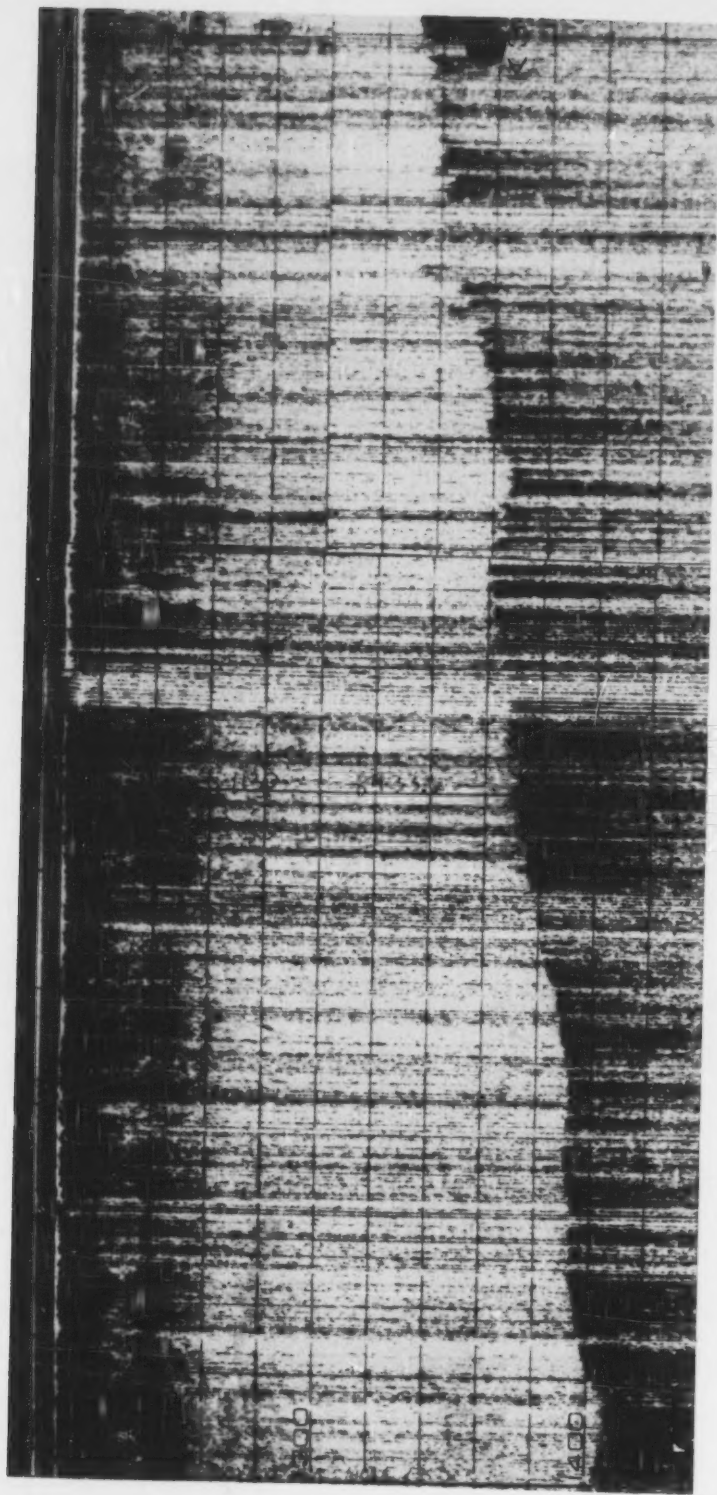


Figure 38-1.--Echogram from 12-kH echo sounder during Vema cruise 12. Low undulations on upper continental rise near Albatross camera station K-3.

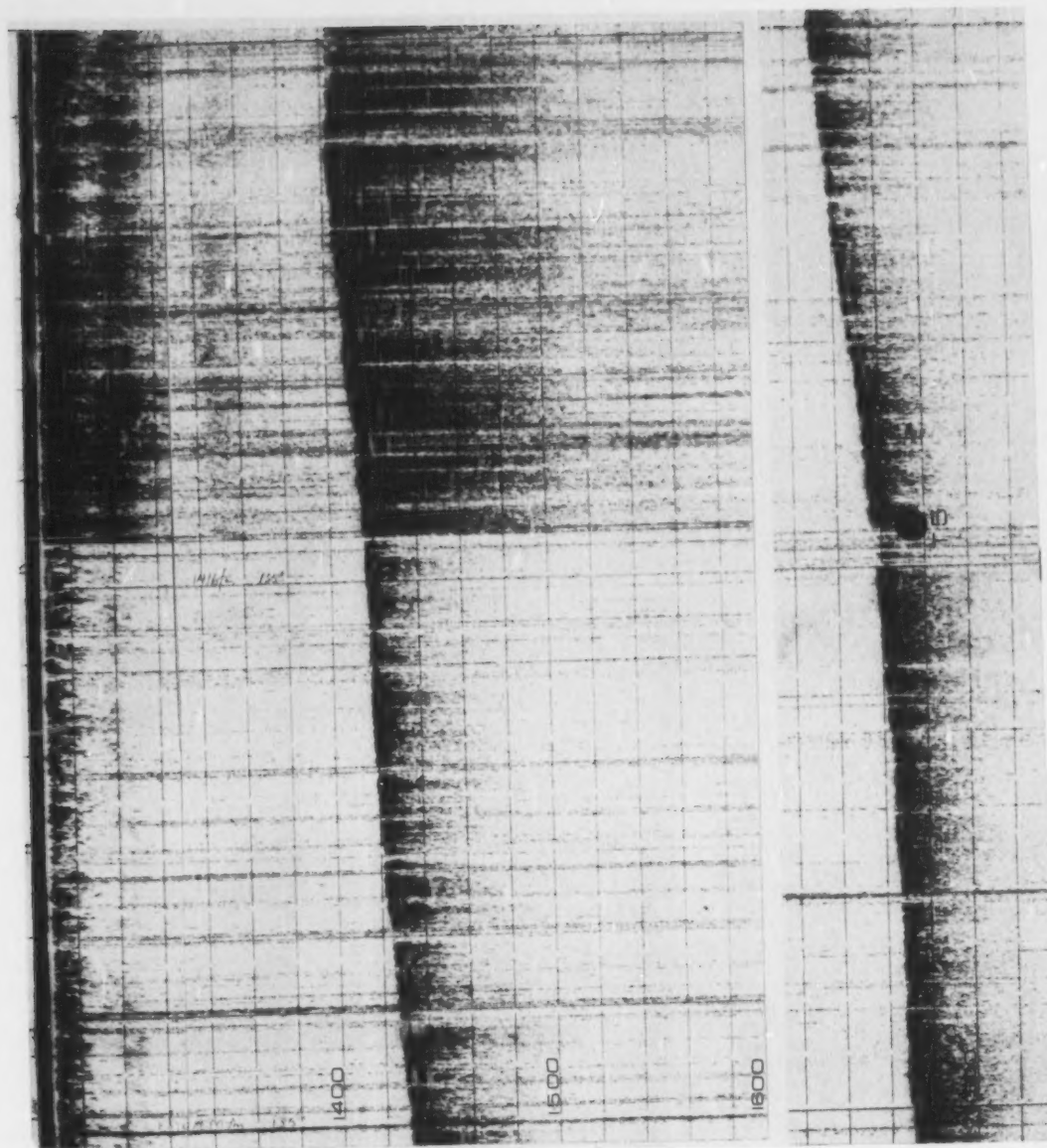


Figure 38-2.--Smooth surface of continental rise in lee of Hudson Canyon and location of camera station T-5.

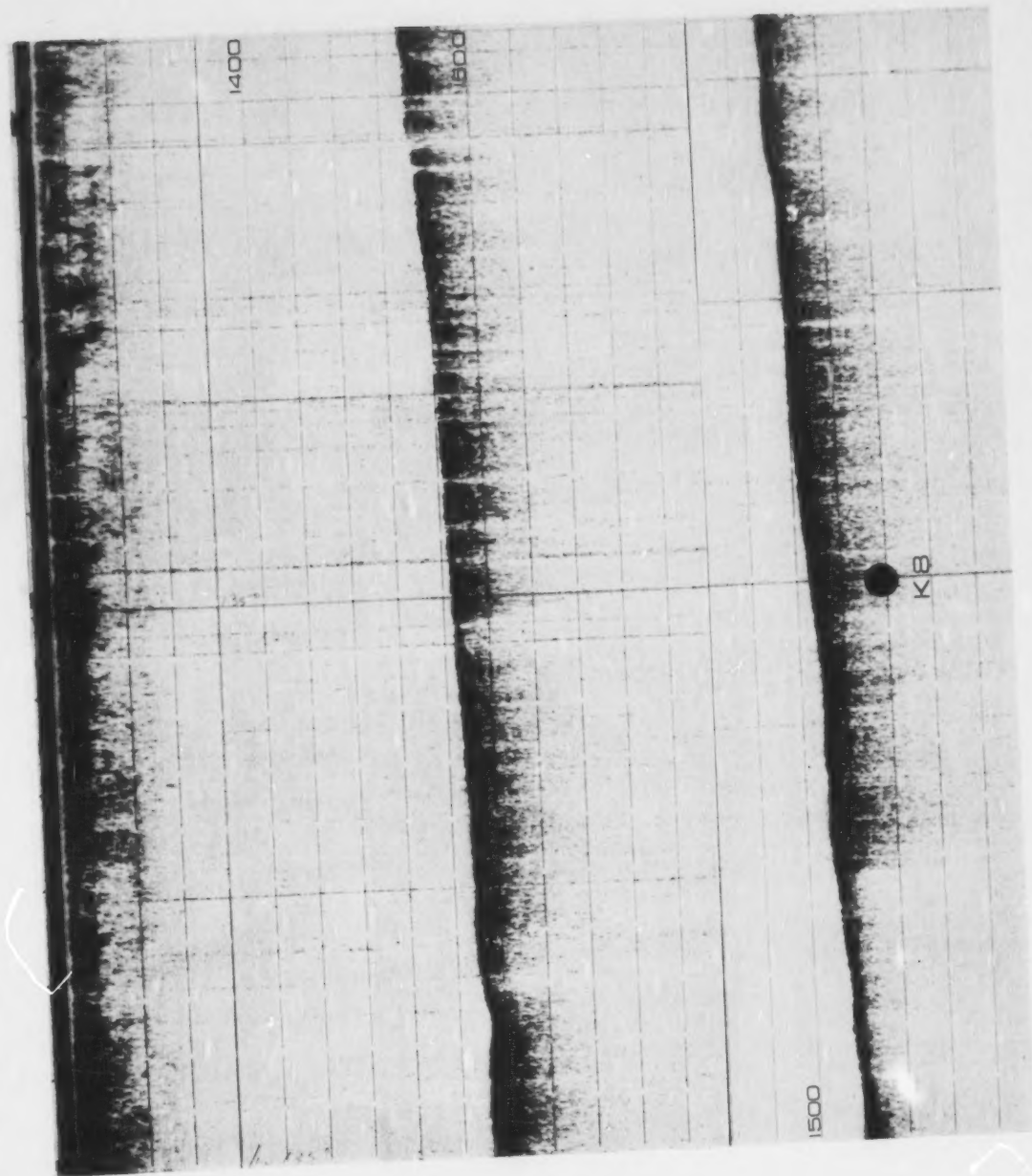


Figure 38-3.--Smooth surface of upper continental rise near location of Albatross camera station K-8.

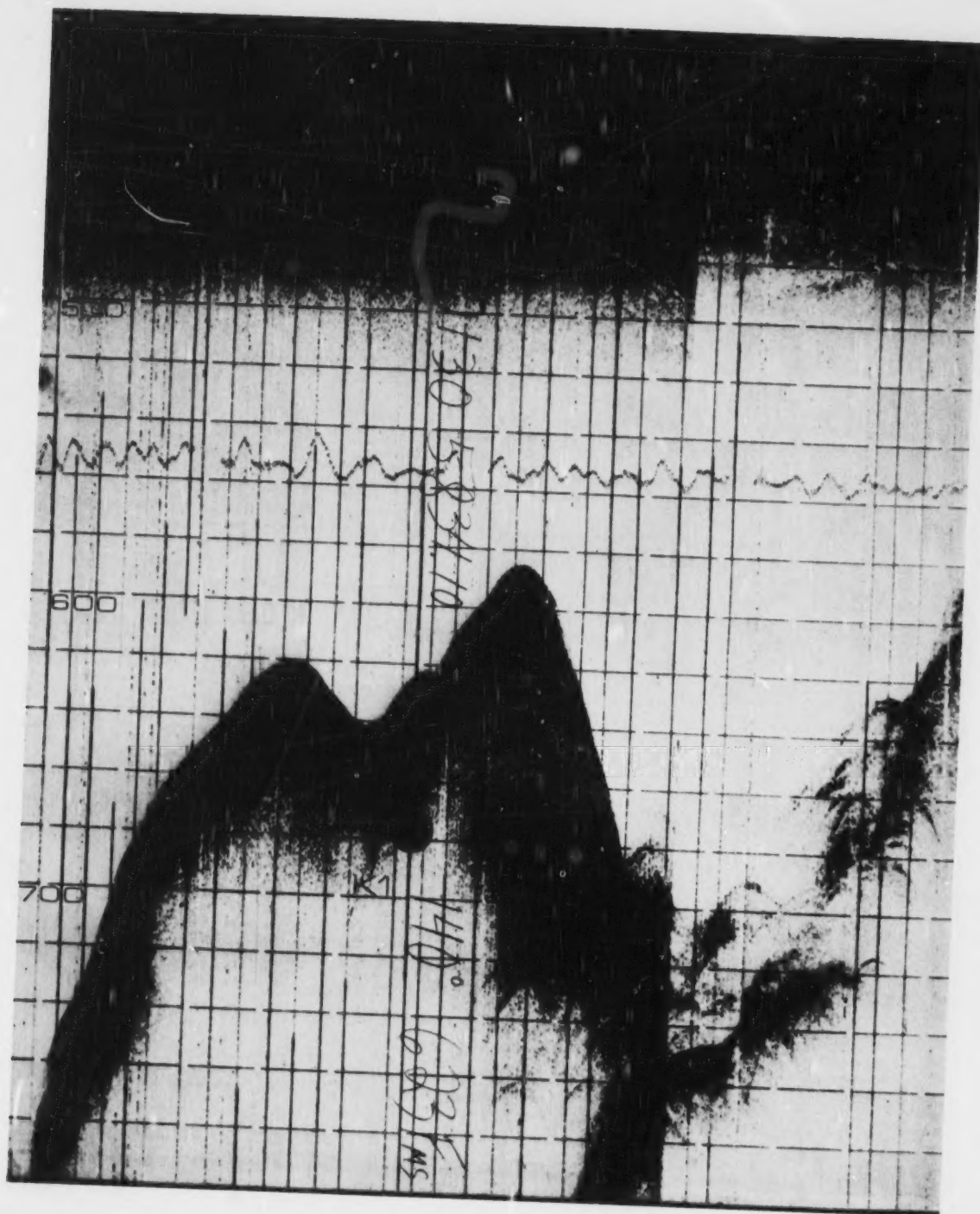


Figure 39-1.--Echogram from 12-kH echo sounder during Vema cruise 20. This track is near camera stations made in 1974 by Albatross IV, which did not have a recording echo sounder at that time. Camera station K-1 on continental slope showed a tranquil bottom.

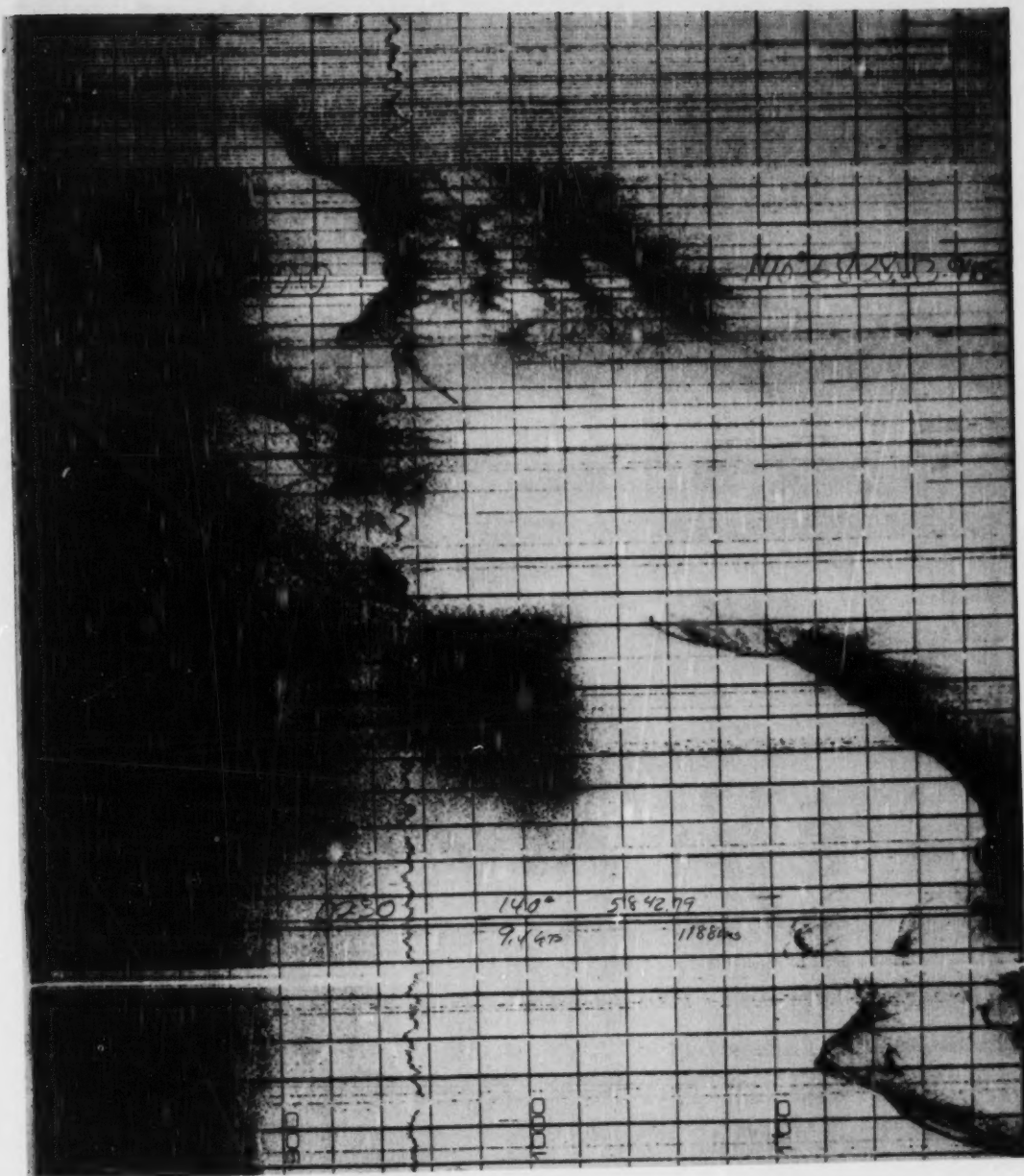


Figure 39-2.--Lower continental slope.

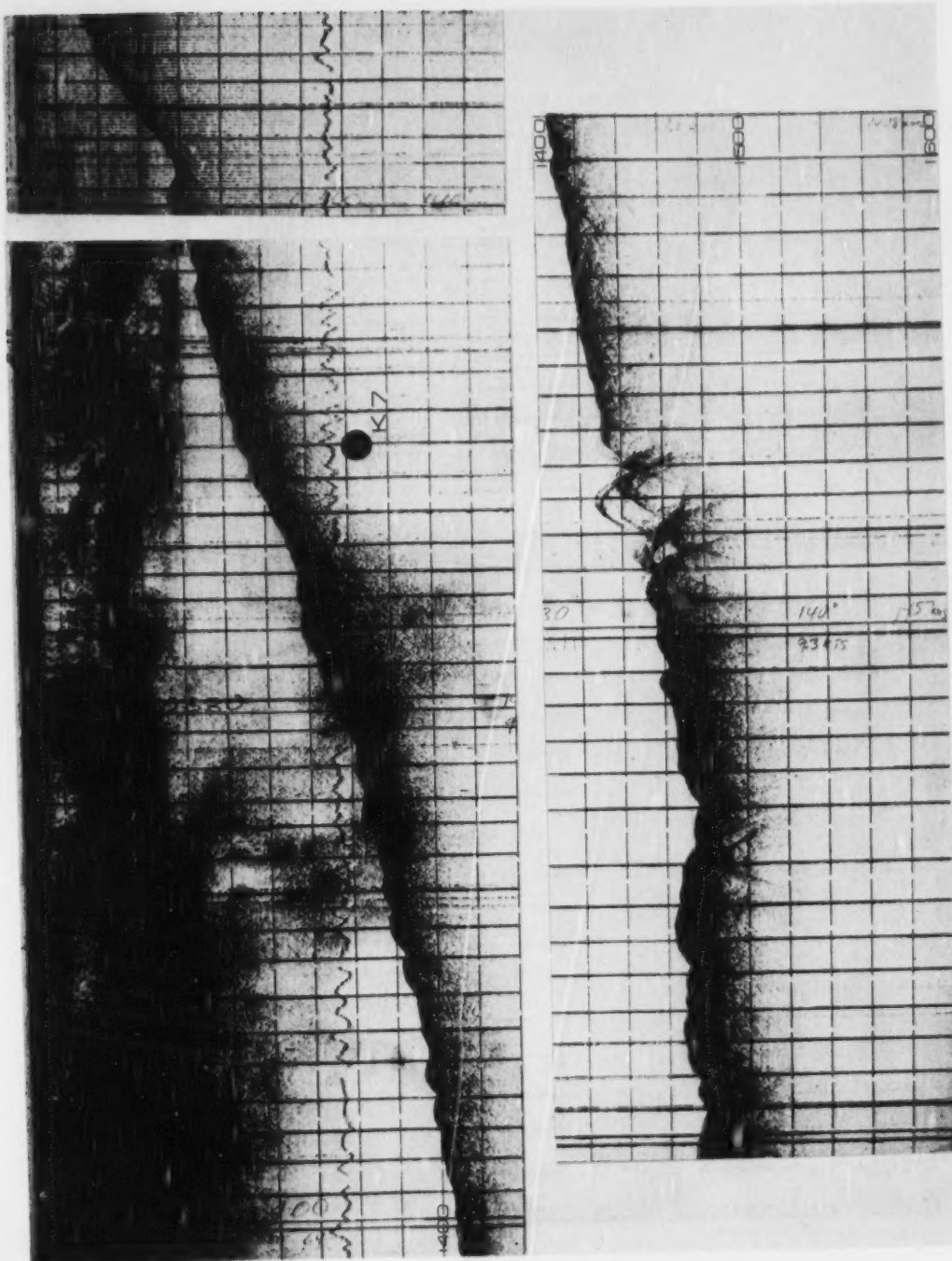


Figure 39-3.--Camera station K-7 was located on some low undulations on upper continental rise near base of continental slope.

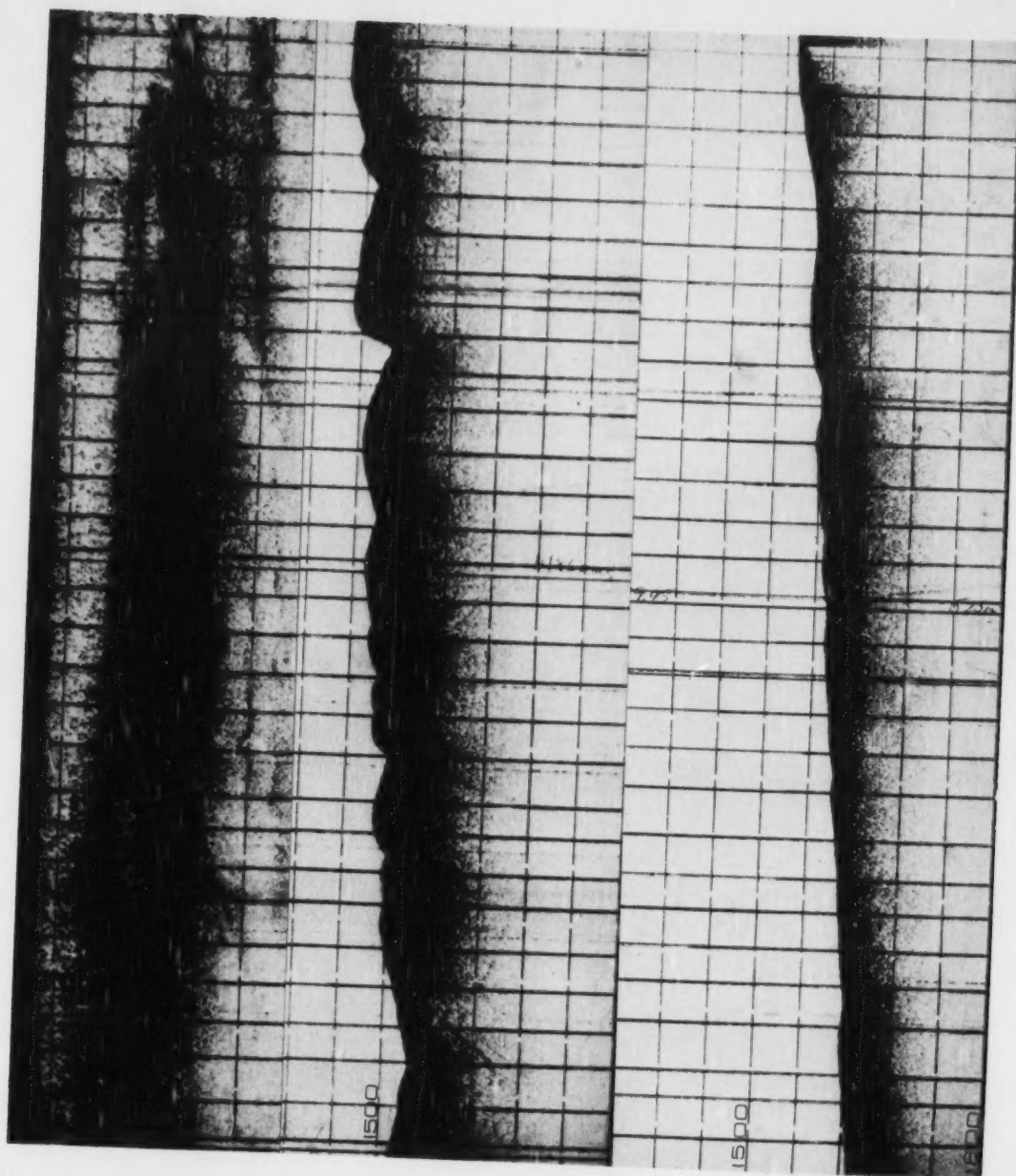


Figure 39-4. --Undulations on upper continental rise decrease in amplitude with increasing depth.

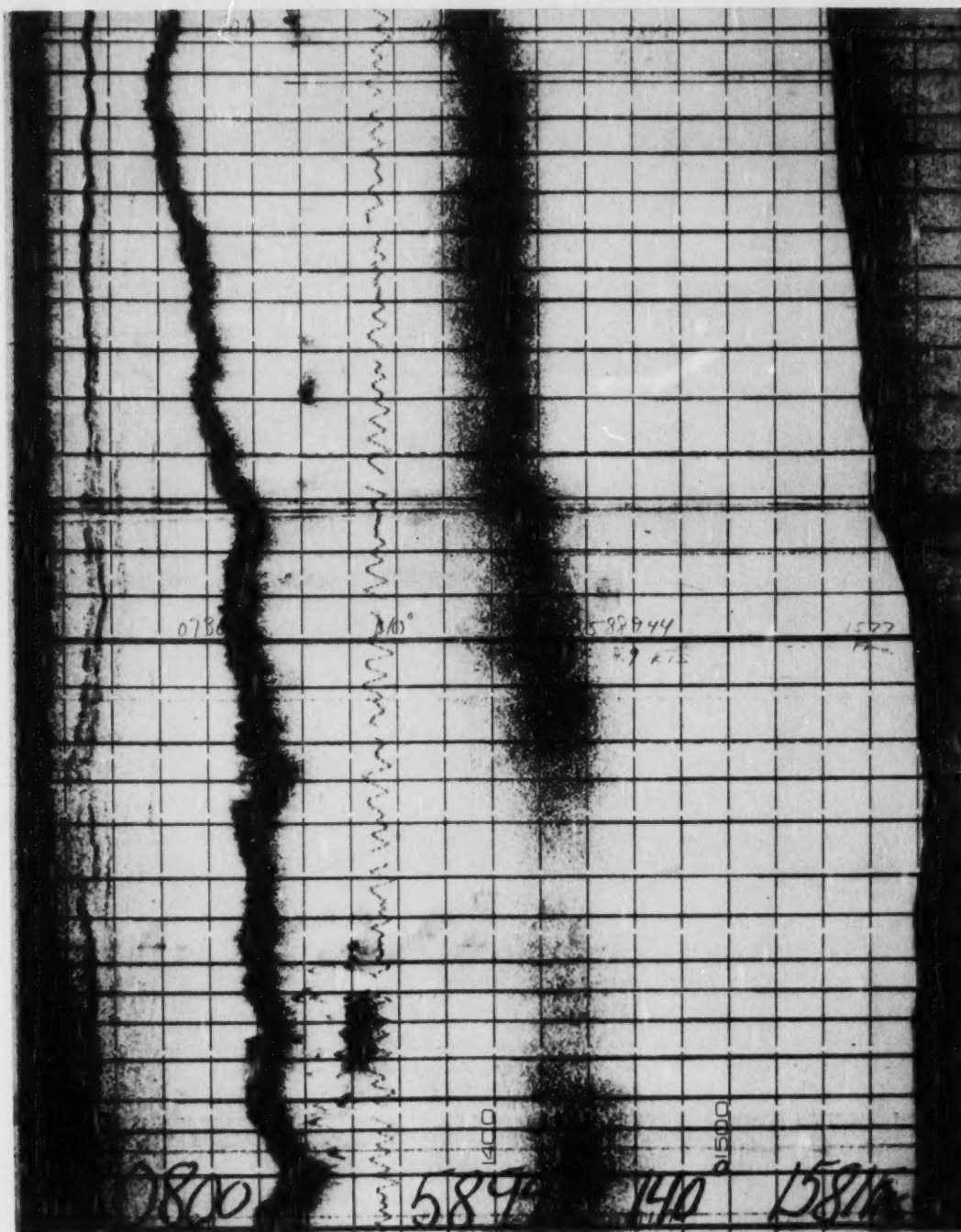


Figure 39-5.--Hyperbolae suggest small-scale bedforms on upper continental rise.

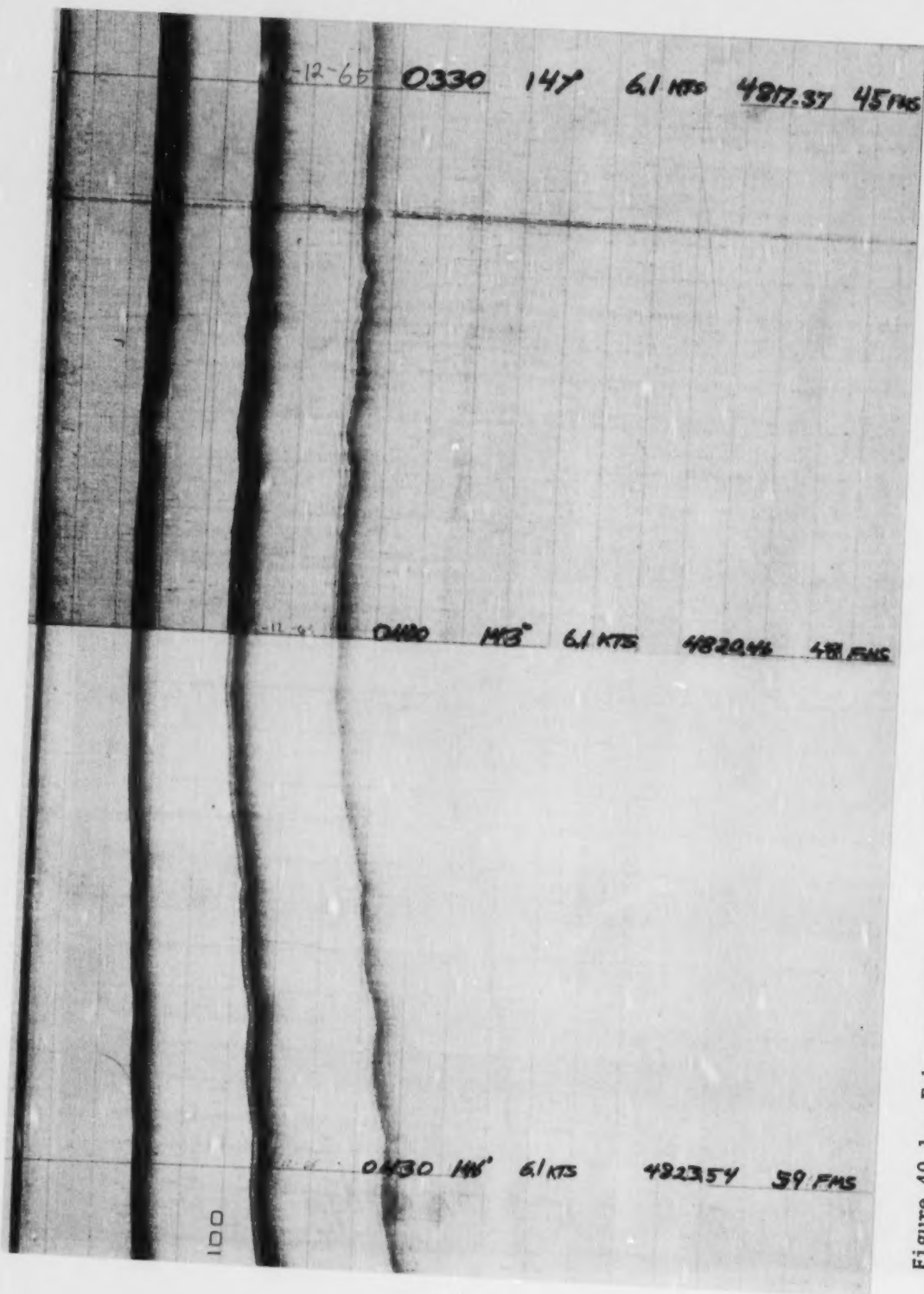


Figure 40-1.--Echogram from 12-kHz echo sounder during Vema cruise 21, continental shelf to upper continental rise. Continental shelf is smooth reflective surface.

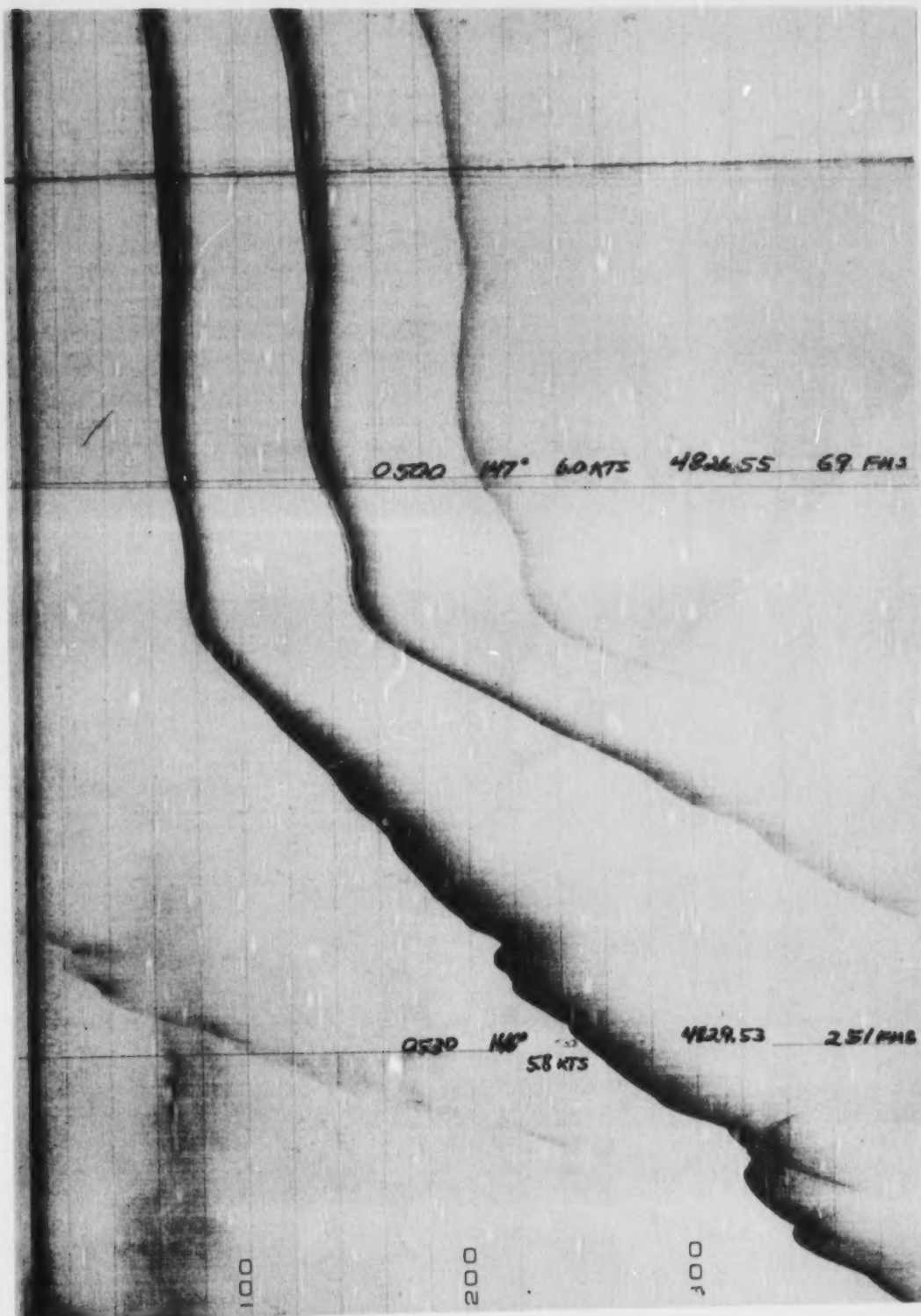


Figure 40-2.--Shelf break and upper continental slope.

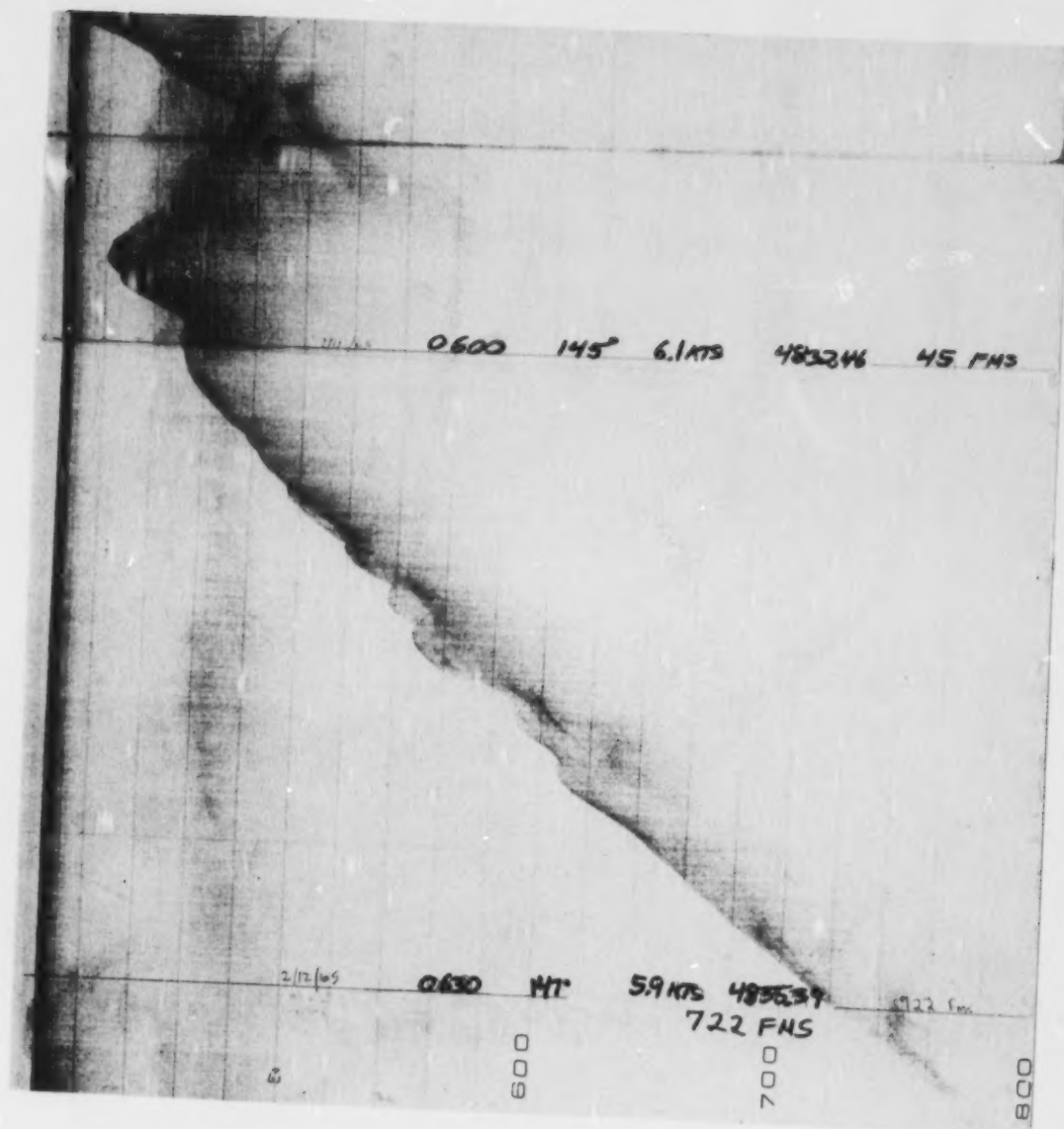


Figure 40-3.--Lower continental slope is irregular.

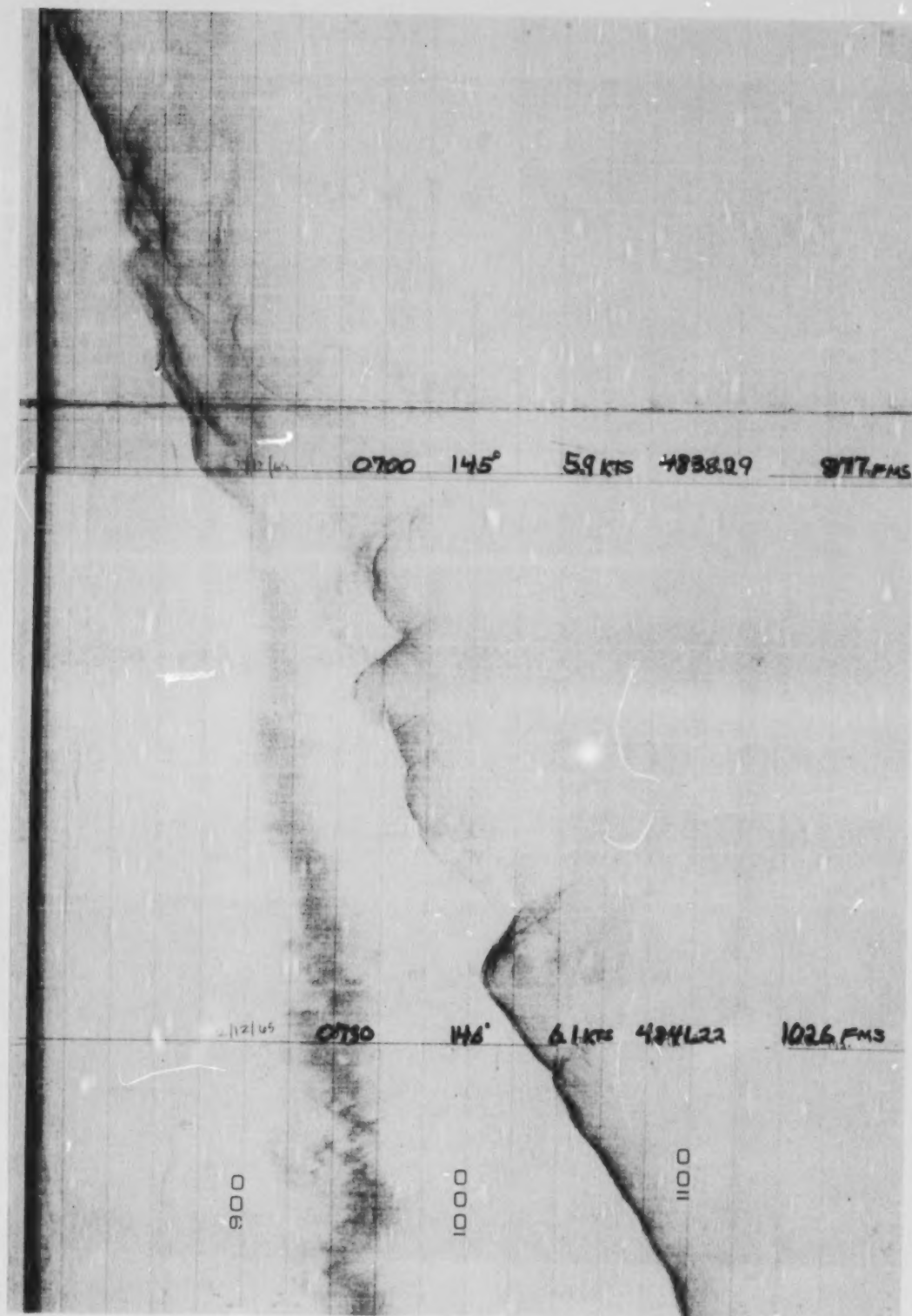


Figure 40-4.--Small channels dissect sea floor near base of continental slope.

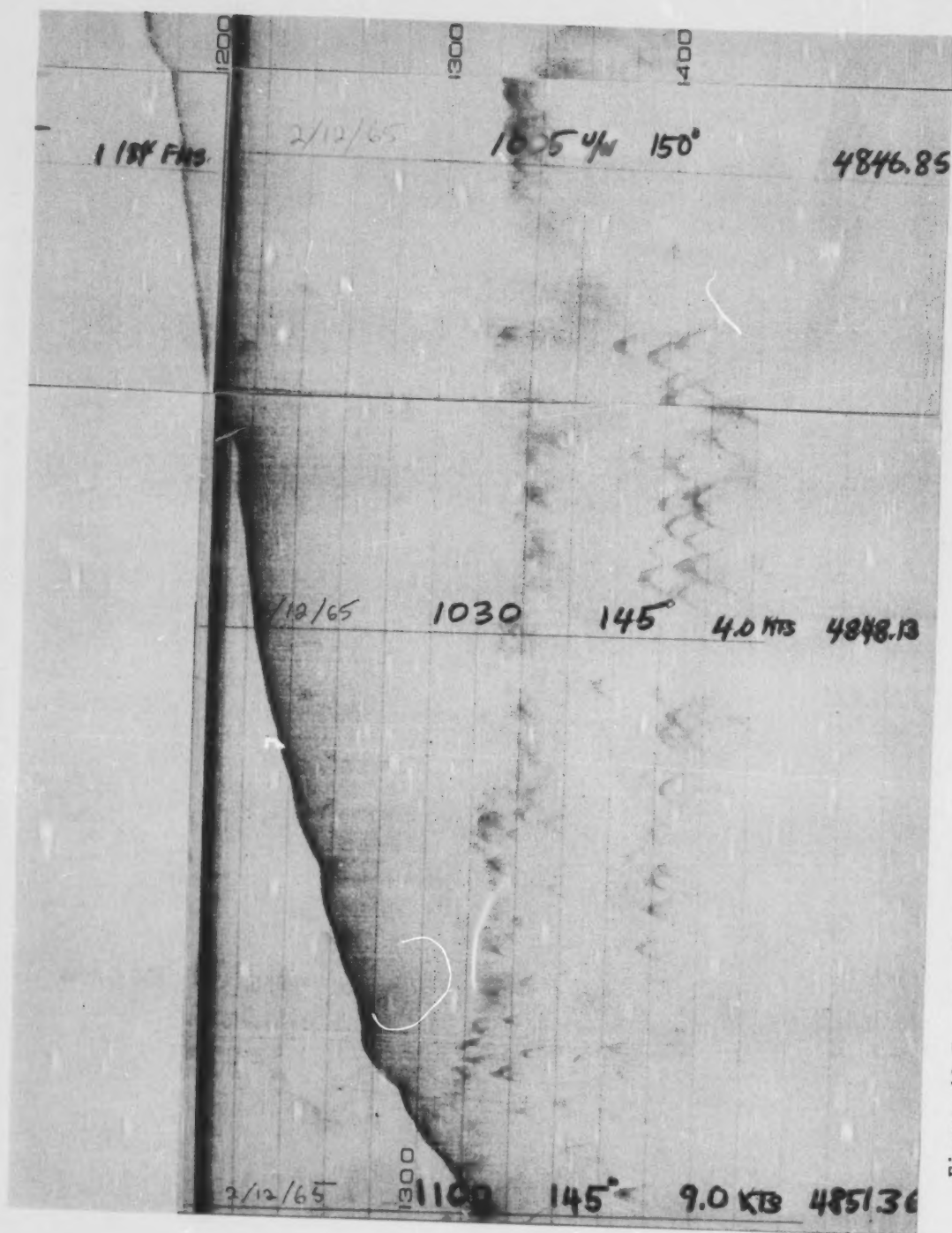


Figure 40-5.--Smooth areas alternate with dissected areas near base of continental slope.

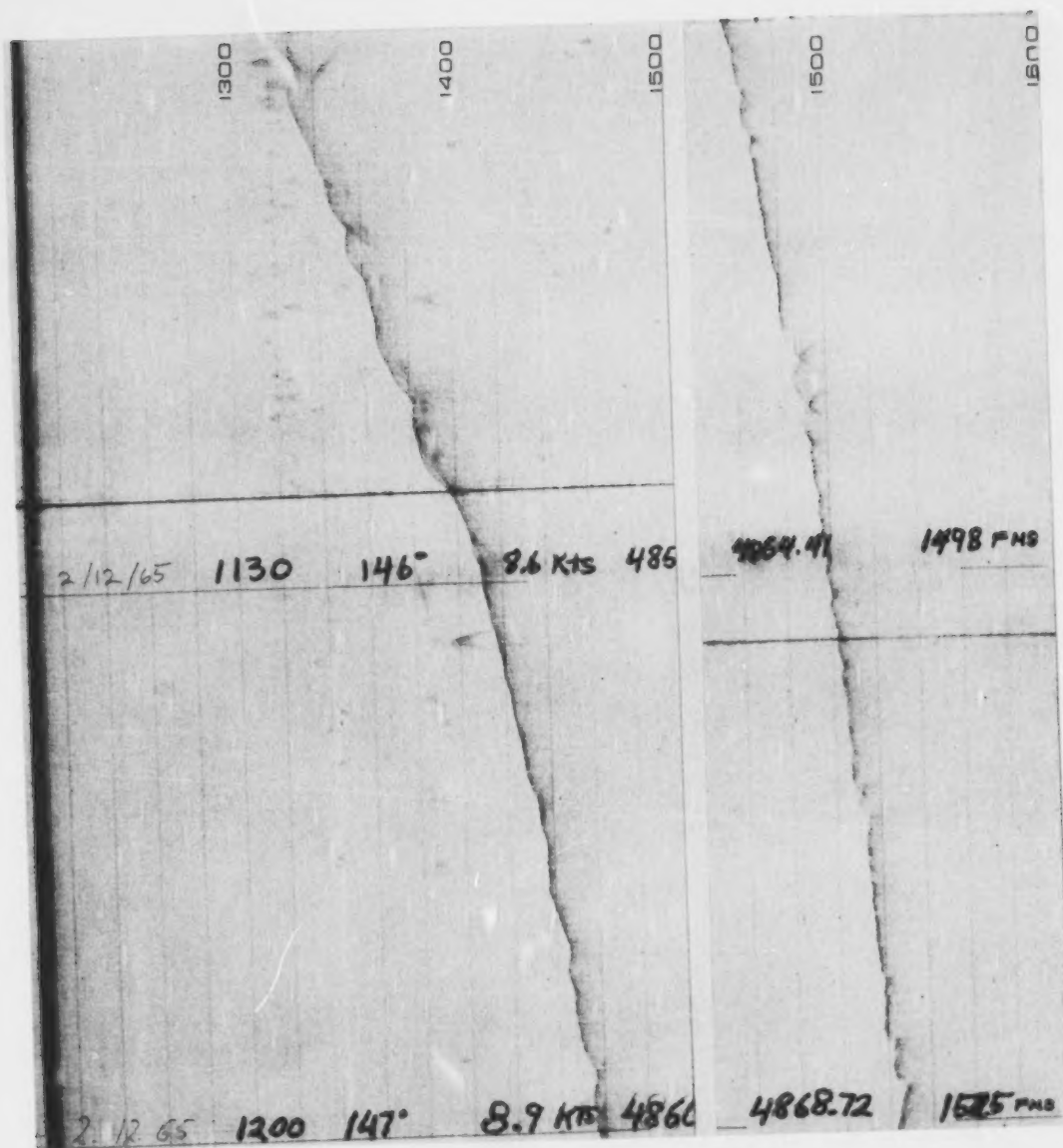


Figure 40-6.--Small-scale irregularities in surface of upper continental rise.



Figure 40-7.---Upper continental rise.

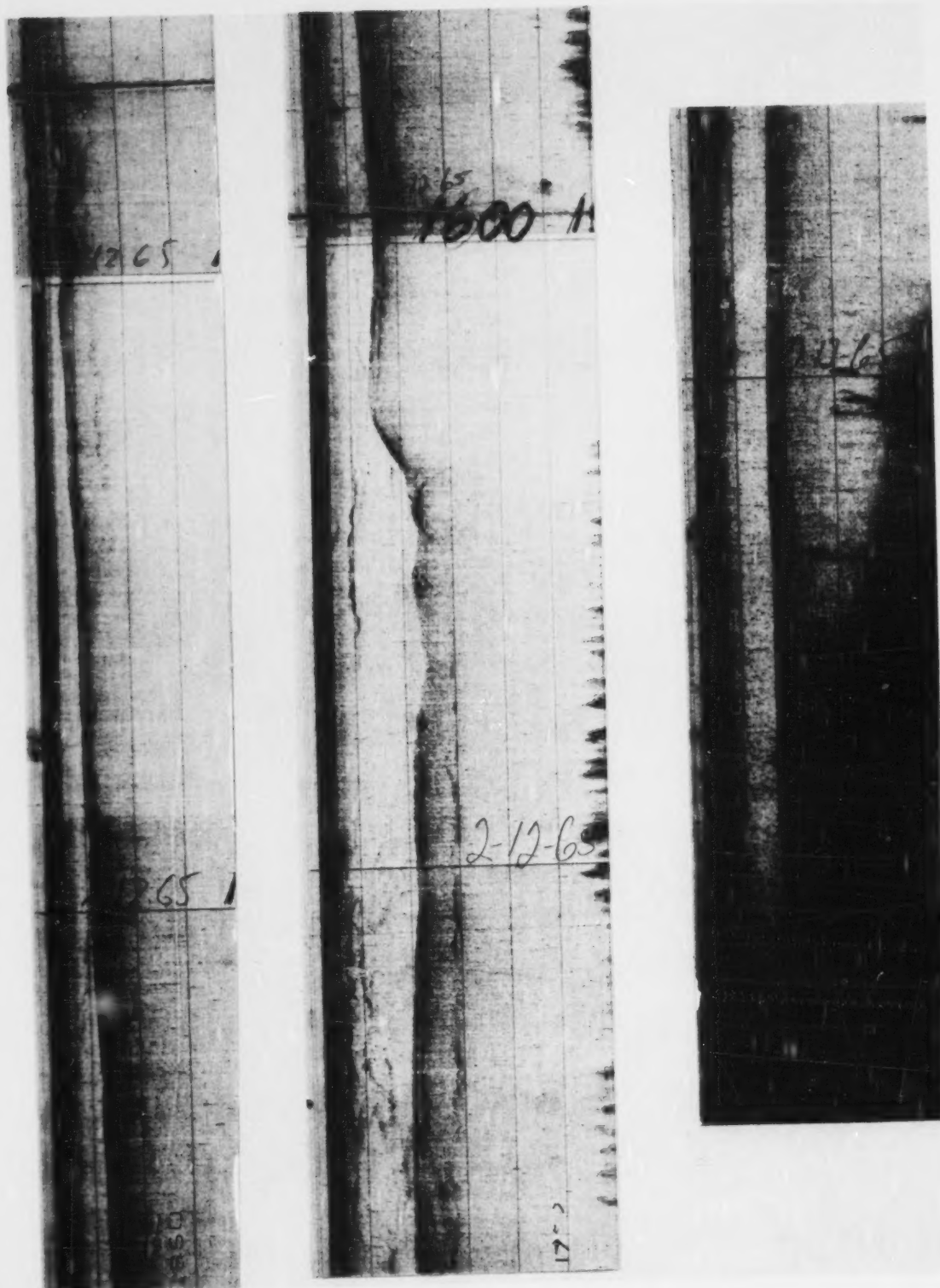


Figure 40-8.--Upper continental rise.

PHYSICAL OCEANOGRAPHY HISTORICAL DATA FOR DEEPWATER DUMPSITE 106

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INTRODUCTION

Deepwater Dumpsite 106 (DWD 106) covers 480 nmi² and is located between latitudes 38°40'N and 39°00'N and longitudes 72°00'W and 72°20'W in 2700 m of water (fig.1). The site is used for dumping industrial wastes (sludge and chemicals) from the northeastern States. The bottom is a repository for unwanted explosives. It is the purpose of this paper to characterize the water column above and adjacent to the site on the basis of historical and field data. This characterization is necessary to help plan at-sea surveys and to provide a data base for use in assessing the feasibility of continued use of the dumpsite.

DWD 106 is just east of the continental shelf, generally in a water mass called slope water. Slope water occupies the area east of the continental shelf and west of the Gulf Stream. The regional limits of slope water are given by Worthington (1964). The southern or eastern boundary is the edge of the Gulf Stream (15°C at 200 m, Fuglister 1954). The north and west boundary is the 200-m bottom depth contour from Cape Hatteras to 63°30'W. East of 63°30'W the northern limit is represented by the contour of the 9°C isotherm at approximately 200 m (Fuglister, 1954). Worthington says that water temperature less than 9°C at 200 m can be traced to Labrador Basin Water.

The bottom topography consists of the continental shelf, continental slope, and the continental rise (fig. 1). The continental shelf is a relatively smooth broad plane; the relief of any irregularities is less than 10 m. The shelf width ranges from 190 km south of New York to 23 km off Cape Hatteras. The slope of the shelf varies from 3' to 7' from New York to Cape Hatteras. The bottom sediment is mainly sand with some gravel. The irregular continental slope occupies the area between the continental shelf and the continental rise and is cut by several canyons with deep channels extending seaward. The slope is about 4°, and the bottom sediments are silt-clay and sandy-silt. Outcrops of bedrock occur in the canyons. The continental rise, between the continental slope and the abyssal plain, has a relief generally less than 40 m, but it can be as much as 300 m. The slope is about 30'. Bottom sediments consist of sandy silt at the base of the continental slope to silt and red clay seaward. Sand beds may be found at the mouths of submarine canyons. (Fisher, 1973).

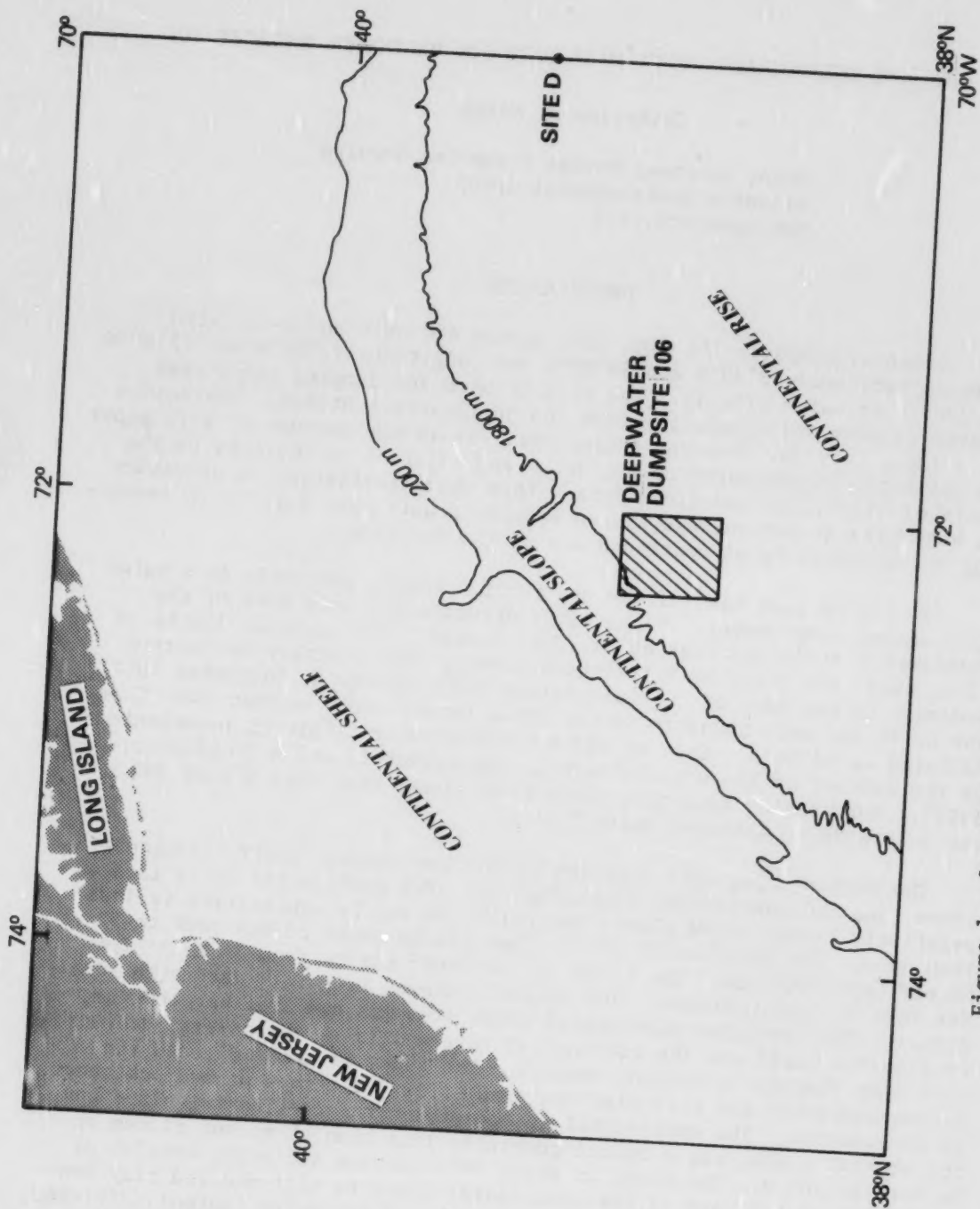


Figure 1.--Location of Deepwater Dumpsite 106 and Site D.

DWD 106 is located over the continental rise about 3 km seaward of the base of the continental slope. The slope of the sea floor is $1^{\circ}25'$ in the north and $57'$ in the south. There are several submarine canyons west and north of the dumpsite, the largest being the Hudson Canyon to the north. (Oceanographer of the Navy, 1972).

Water over the continental shelf is called coastal or shelf water (fig. 2) and has large seasonal variations. Shelf water is northern coastal water off Canada which moves southward over the continental shelf and is modified by land drainage and the atmosphere (Cresswell, 1967; Fisher, 1973). In winter, the salinities and temperatures are much lower than those of slope water. In summer, surface temperature over the shelf may become indistinguishable from surface slope water; salinity also increases over the shelf but remains lower than that of slope water. Between Cape Cod and Cape Hatteras sea surface temperature ranges annually between 0° and 27°C . Salinity increases from 32 to 33.5 o/oo in midshelf to 34 to 35 o/oo near the shelf break (Bigelow and Sears, 1935). Isohalines tend to parallel the coast.

The Gulf Stream has small seasonal variations and always has higher temperatures and salinities than slope water. The mean annual range of surface temperature for the core of the Gulf Stream is between 22° and 29°C . Surface salinity is 36.0 ± 0.2 o/oo. (Fisher, 1973)

Slope water is more characteristic of oceanic water and has a temperature-salinity ratio very similar to North Atlantic Central Water (NACW). Mean annual sea surface temperature for slope water south of New York ranges from 10° to 26°C . Slope-water salinity will be defined as above 33.5 o/oo.

Iselin (1936) defines slope water as a mixed zone for shelf water and Gulf Stream water. Below 200 m he finds that the average temperature-salinity curve is slightly fresher than North Atlantic Central Water, and at a depth of approximately 900 m slope water "becomes indistinguishable from North Atlantic Deep Water." Between temperatures of 10° and 4°C the depths of the slope water temperature-salinity curve range between 240 and 900 m, and the NACW temperature-salinity curve for this temperature range is from 900 to 1600 m (fig. 3).

Slope water east of Georges Bank was found to be slightly fresher than slope water defined by Iselin (1936) west of Georges Bank (McLellan, 1957). This is perhaps due to the greater influence of coastal water in the region McLellan sampled. McLellan (1957) shows slope water temperature-salinity characteristics to be between those of shelf and Gulf Stream water. The ranges of each are shown in figure 4a and 4b. Figure 4a shows the upper 150 m for June 1952, and 4b shows temperature-salinity relationships below 100 m.

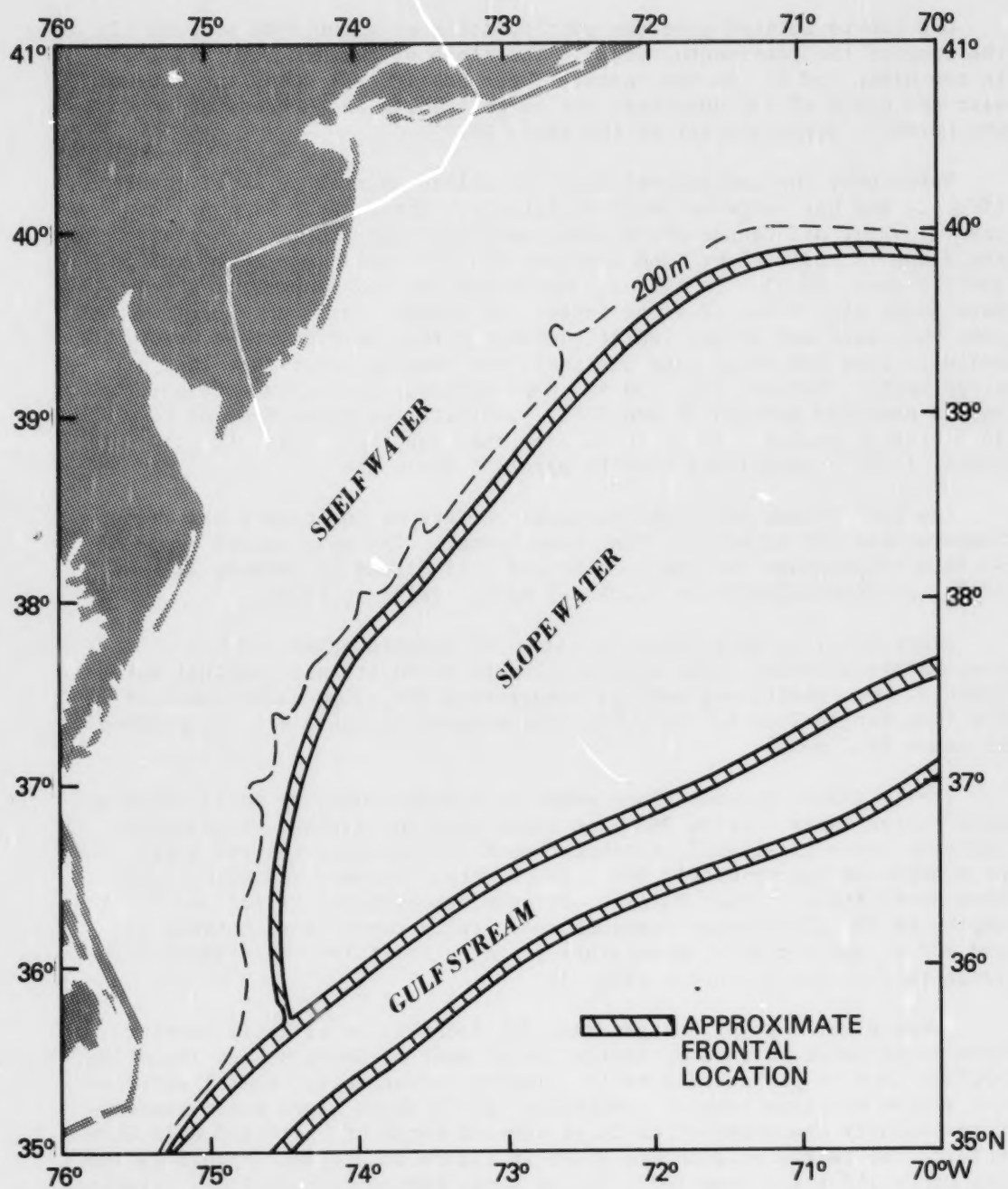


Figure 2.--Approximate positions of water masses (in part after Fisher 1973).

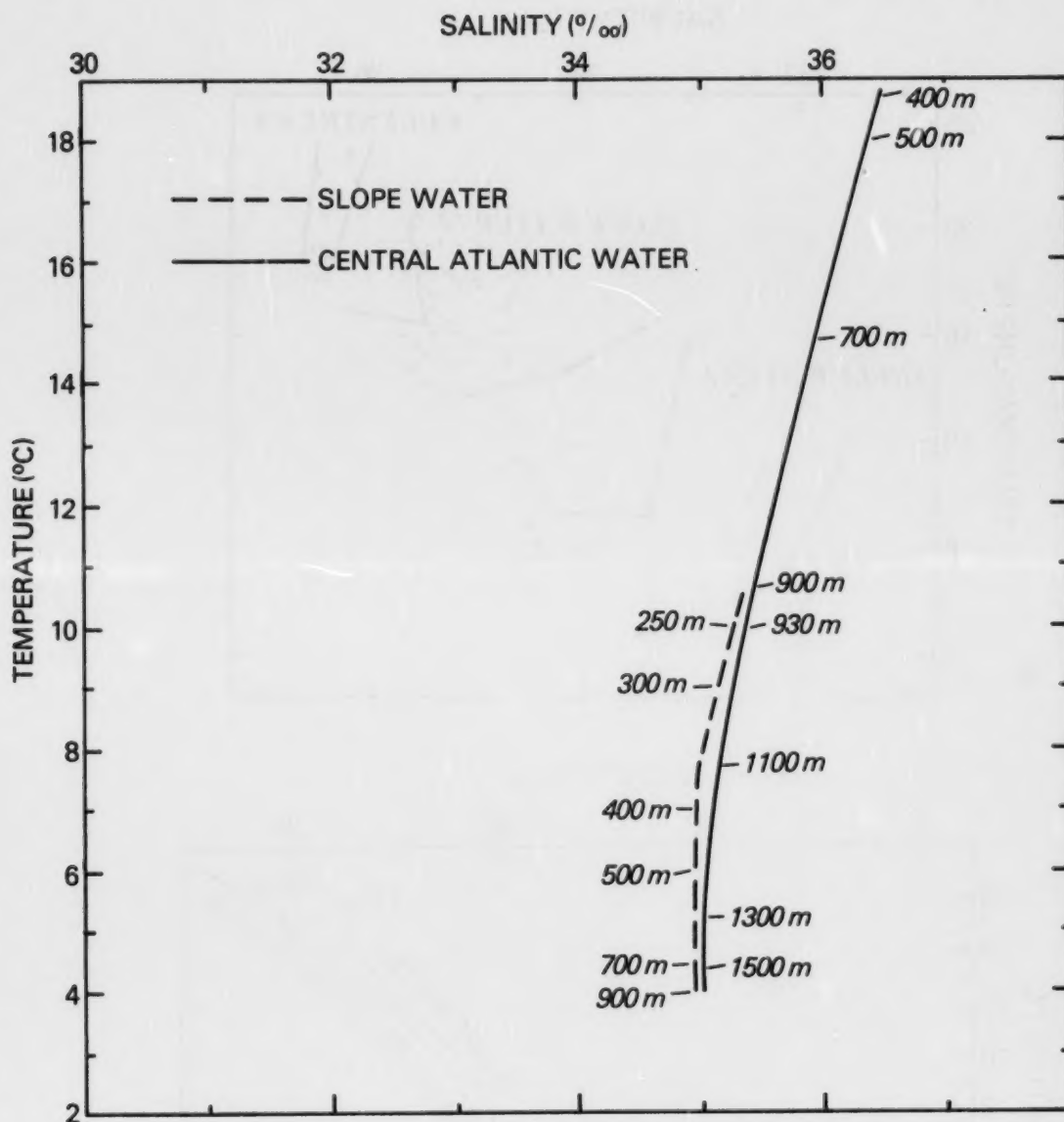


Figure 3.--Comparison between mean temperature-salinity correlations of slope water and Sargasso water. Atlantis sections Chesapeake Bay to Bermuda (after Iselin 1936).

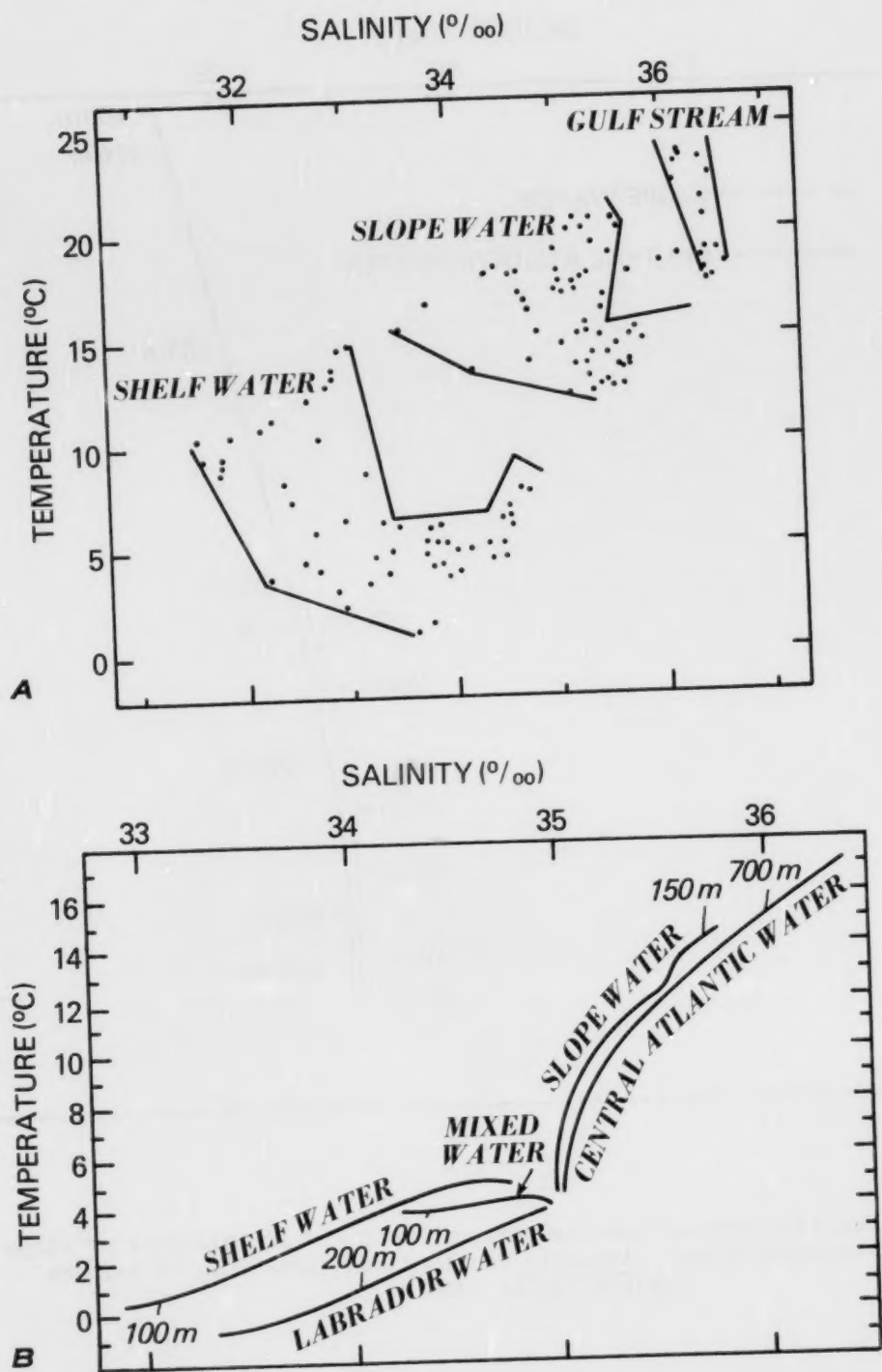


Figure 4.--Temperature-salinity relations east of Georges Bank, June 1952 (after McLellan 1957). A, upper 150 m; B, below 100 m.

The Oceanographer of the Navy (1972) states some temperature and salinity generalities concerning DWD 106. These will be discussed in more detail below. Sea-surface temperature falls between 5° and 26°C. Salinity ranges between 31.5 o/oo and 35.5 o/oo. At 2500 m the average temperature and salinity are 2.9°C and 34.94 o/oo, respectively. From January through March in the upper 150 m temperature usually increases with depth, with some occurrence of temperature inversions. The mixed layer varies throughout the year. It extends to between 15 and 50 m during the spring and summer and to 100 m during the fall and winter.

Fisher (1973) attempts to describe shelf, slope and Gulf Stream water on the basis of temperature. He says that while each water mass has a distinct thermohaline relationship, a temperature profile can "provide a reasonably accurate water mass identification." He further tries to describe the shelf/slope and slope/stream boundaries on the basis of temperature structure. At these boundaries strong fronts can occur. These can be detected by horizontal temperature gradients. Mixing occurs across frontal zones when shelf water or Gulf Stream water overrides slope water, or when inversions occur. Observations have shown shelf water overlying slope water to 100 km seaward of the 200 m isobath and to depths exceeding 50 m (Fisher, 1972a). Fisher says that this is

probably a result of wind driven advection. McLellan (1957) notes that shelf and Gulf Stream water sometimes meet in the region south of Georges Bank. Bathythermograms are shown in figure 5 as representative of the three water masses and their boundaries (Fisher, 1973). Fisher (1972a) identifies water masses at 200 m and at 400 m where appropriate. These are shown in table 1. Spacial and temporal effects at 200 m and below can be considered negligible. Water properties in the upper 200 m are highly variable, with large seasonal changes in temperature and salinity. At times the surface slope water is overrun by shelf or Gulf Stream water.

Table 1. Temperature characteristics of water masses at 200 and 400 meters

Water mass	Temperature characteristics (°C)
Sargasso	$T_{200} \leq 17.0^\circ$ and $T_{400} \geq 16.5^\circ$
Gulf Stream	$15^\circ \leq T_{200} < 17.0^\circ$ and $T_{400} < 16.5$
Slope	$9^\circ \leq T_{200} < 15.0^\circ$
Scotian	$T_{200} < 9^\circ$
Shelf	Bottom depth less than 200 m

¹ After Fisher, 1972a. T200 = temperature at 200 m; T400 = temperature at 400 m.

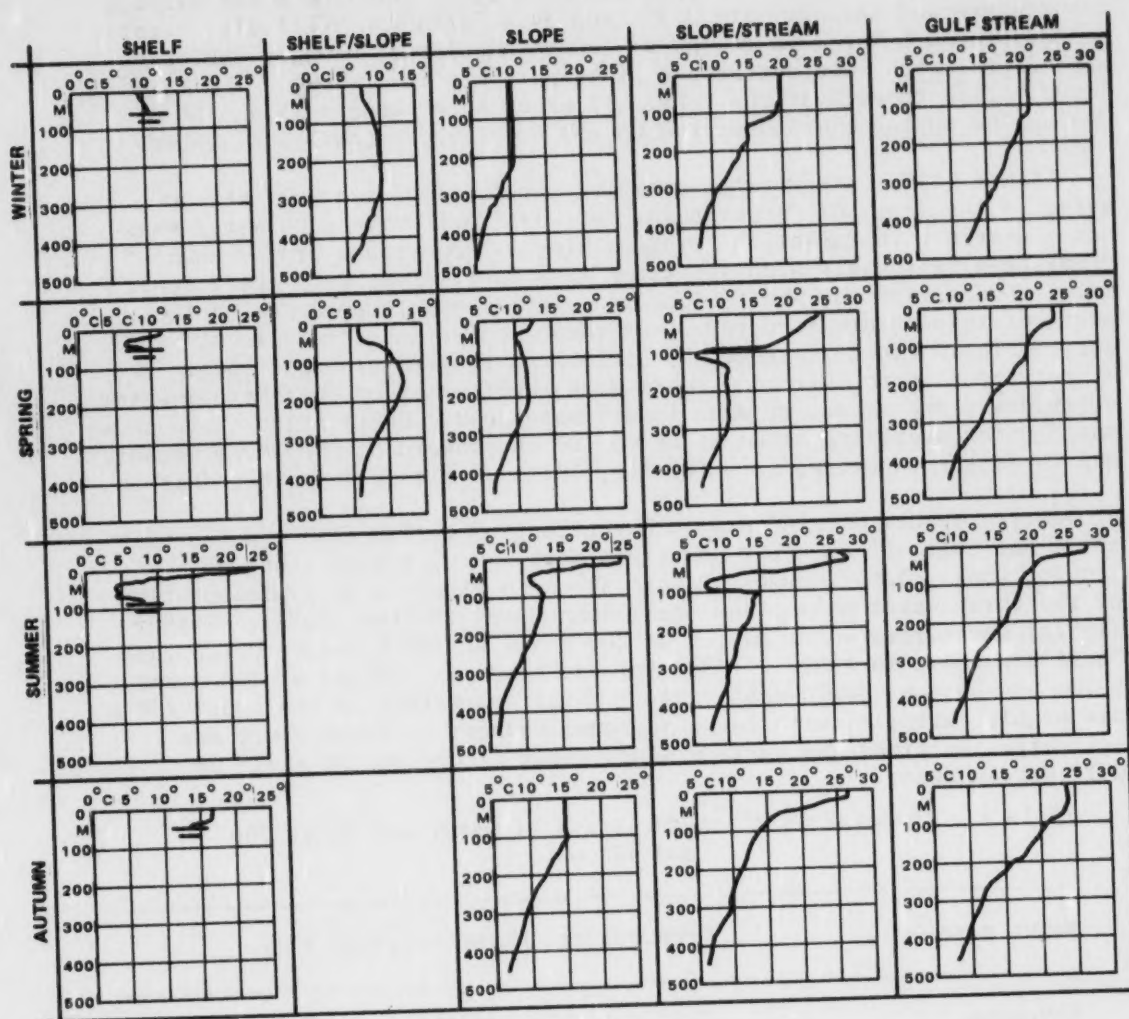


Figure 5.--Seasonal bathythermogram characteristics by season and water mass (after Fisher 1973).

CIRCULATION

Little is known of the circulation in the area of the deepwater dumpsite, although waters shoreward and seaward of this site have been studied extensively. Shoreward is shelf water, where currents run predominantly southward along the coast. Seaward the Gulf Stream system at this latitude flows generally northeastward. Between these two water masses is slope water, which Fisher (1973) suggests may circulate in a cyclonic gyre. The surface circulation in this area may be highly variable and a function of season. The three water masses interact. The discussion that follows is an attempt to characterize the circulation patterns in the deepwater dumpsite area.

Shelf Water

The continental shelf in the area between Great South Channel and Cape Hatteras is known as the Middle Atlantic Bight area (fig. 6). The circulation of the water in this region has been discussed by Bumpus (1965, 1969, 1972), Bumpus and Chase (1965), Chase (1969), Miller (1952), Iselin (1939, 1940), Powers and Ayers (1951), Meade (1969), Shonting (1969), McClennen (1973), Costin, Davis, Gerard and Katz (1963), Haight (1942), and others.

In the vicinity of Long Island the coastal drift is westward. It changes to southward and southwestward along the Middle Atlantic States and turns seaward in the vicinity of Cape Hatteras below Chesapeake Bay (Bumpus, 1972; Haight, 1942; Powers and Ayers, 1951). Bumpus (1972) suggests that the surface drift has a slight shoreward component during the winter months. In summer, land runoff is lower, and there is an increase in salinity over the shelf. During winter, the winds are predominantly from the west, and the horizontal density gradients are weak in waters over the shelf. Iselin (1939, 1940) reports an offshore component in surface currents in coastal waters (caused by land runoff) and an inshore subsurface component. He also notes that because coastal waters are fresher, and therefore less dense than corresponding layers offshore, a southwest current is maintained. From December through February, the isopycnals parallel the coast, there is less dense water near shore, and the horizontal density gradient weakens seaward. Strong westerly winds during this period can alter the geostrophic flow.

From the recovery of drift bottles Bumpus further delineates the surface circulation over the Middle Atlantic Bight by dividing the region into a two-celled system. The northern cell lies northeast of the Hudson Canyon. During the spring this cell receives offshore indrafts from south of Nantucket Shoals and from Georges Bank across South Channel. This water moves towards Rhode Island and then takes on a southward flow. There is a compensating offshore drift east of Hudson Canyon. This countercurrent may shift with time. "It appears largest and closest to shore when the indraft south of New England is most vigorous" (Bumpus,

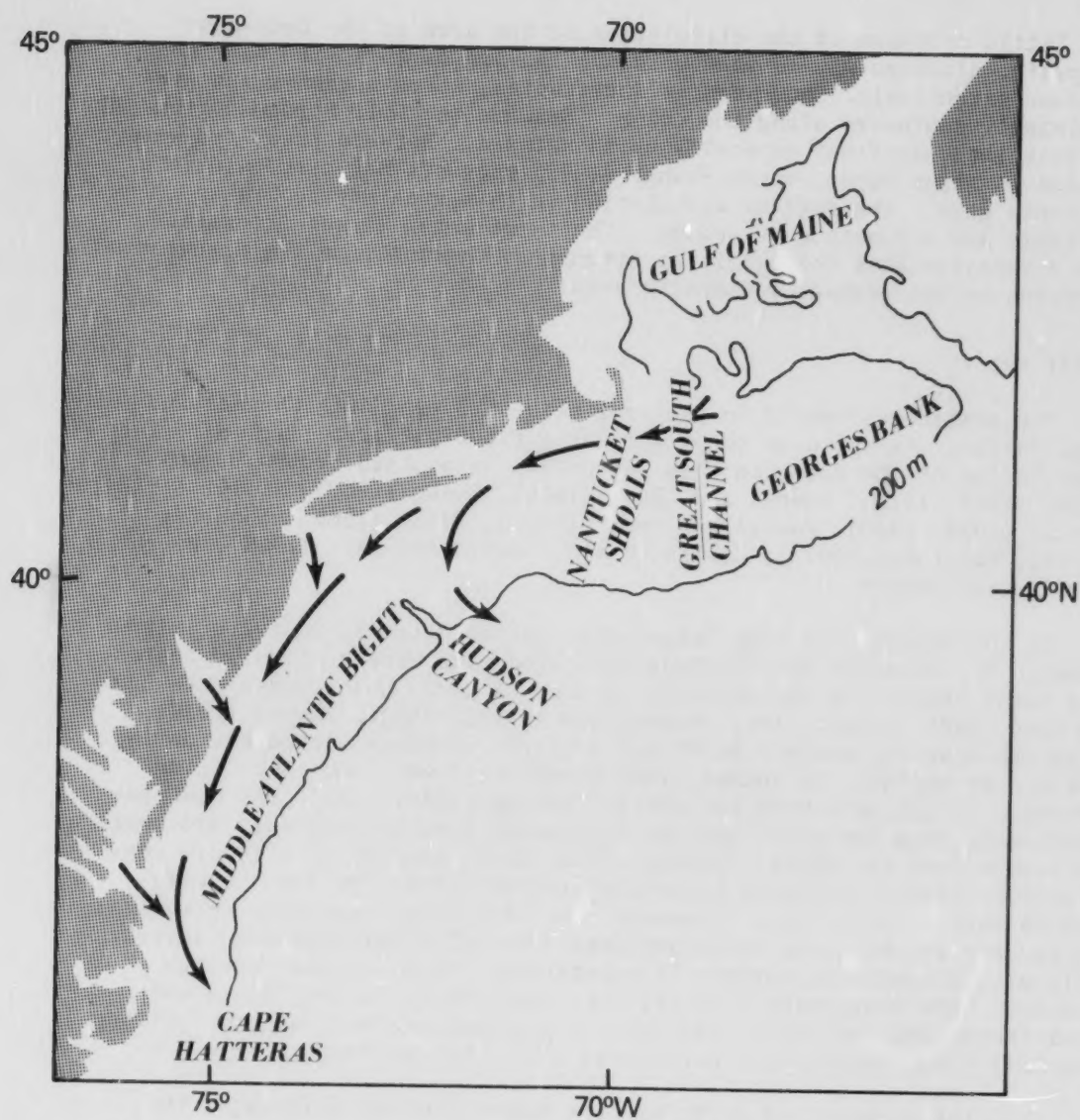


Figure 6.--Two-celled circulation over Middle Atlantic Bight inferred from surface drift bottle data by Bumpus (1973).

1972). The inflow decreases through September; the flow is then westward to southwestward and is well defined along the coast. Drift bottle data suggest there may be an increase in the offshore component during the winter (fig. 6).

The southern cell of the two-celled system lies between Hudson Canyon and Cape Hatteras. Few indrafts from offshore have been observed in this region. The inflow to this cell is primarily from the rivers along the coast. Beginning with the Connecticut River the flow is southward towards Cape Hatteras.

Miller (1952), and Powers and Ayers (1951), found that from the southward nearshore drift many offshoots and cyclonic eddies occur. Costin, Davis, Gerard, and Katz (1963)--who performed dye experiments at Ambrose lightship and at the head of the Hudson Canyon--found weak cyclonic eddies close to New Jersey. They maintain that the eddies aid in transport of river effluent.

Surface current reversals may occur from April through September if the runoff is lower than usual in March through May, or when there are southerly winds (Bumpus, 1969). During reversals, salinities in the Bight are higher. Chase (1969) points out that salinities show an increase from midsummer through winter. Reversals do not usually occur after autumn because the wind shifts to westerly and northwesterly.

Circulation off the mouths of estuaries depends largely on the strength of river flow, winds, and stability of the water column. Norcross and Stanley (1967) in a study of the Chesapeake Bight found that while the surface drift is generally southward a northward flow can develop with low runoff or with southerly winds and a highly stratified water column. Reversals have been noted 40 nmi offshore but usually occur within 30 nmi of shore.

Bumpus (1965, 1972) found the residual bottom drift to be variable and the direction to completely change at times. He also found indications of a net onshore flow. Using seabed drifter data he found the drift over the shelf to be westward to southwestward. The bottom circulation reflects thermohaline circulation, but may be modified by the wind. He also suggests a residual drift toward the mouths of estuaries. Meade (1969) found that bottom waters which move into the mouths of estuaries carry bottom sediments that have mineral components derived from offshore.

Shonting (1969) used current meters to study surface drift and bottom currents in Rhode Island Sound. He found the mean surface drift to be westward to southwestward and the bottom flow to be random and rotary. He also found the mean motion kinetic energy above the pycnocline to be four to five times greater than at the bottom.

McClennen (1973), in a study of the sedimentary processes off the New Jersey Continental Shelf, placed four current meters 1.5 m to 2 m above the sea floor in 30-m, 59-m, 74-m, and 143-m depths. From the data he found that the mean speed is close to the mean speed versus depth curve for Site D (a deep-ocean station; Webster 1971). He suggests that this "may indicate the presence of oceanic circulation shoreward of the shelf break." McClennen also observed that the net drift for the four sampling sites approximately paralleled the topographic trend, but the observed flow for each current meter generally did not parallel the local topography. For the deep current meter he did not find any dominant flow direction and "no directional restricted flow at the other sites." He surmised from this that the local flow variations do not control the topography, nor does the topography control the local fluctuations in flow, but that shelf sediments may be eroded and transported by mean flow up to 30 percent of the time with a southwest bias.

Bumpus (1965) draws a line of divergence along the shelf bottom at the 60-m and 70-m line. Shoreward of this line "the tendency is for the flow near bottom to be westward or southward with a component toward the coast." Seaward "the tendency is toward an offshore drift." This line may move seaward or shoreward. Bumpus suggests its movement is probably seasonal. He is the only one who shows this possible line of divergence. There are no other data in support of diverging flow on the bottom. There is also no evidence for a line of convergence at the surface to compensate for the diverging flow at the bottom.

Slope Water

Seaward of the shelf one enters water more oceanic in characteristics. This water is called slope water (fig. 2). Exchanges between shelf and slope water occur in all seasons. Iselin (1939, 1940) suggested exchanges between shelf and slope water continuously on a small scale, and possible large offshore movements along the 200-m line.

Little is known of the circulation of slope water. On the shoreward side of the slope water region the currents are thought to be southward to Cape Hatteras where they turn seaward. Bumpus (1972) shows evidence from drift-bottle data that during the warm months (April-September) some water may flow around Cape Hatteras into Raleigh Bay. Along the northern wall of the Gulf Stream a northeastward flow exists. This flow may vary due to an eastward flow of shelf water over slope water.

Miller (1950) found major transfers occurring between surface slope water and shelf water south of Rhode Island along the 200-m line. Ford and Miller (1952), Ford, Longard, and Banks (1952), and Fisher (1972b), studied the seaward movement of coastal water near Cape Hatteras. They "found a narrow discontinuous band of relatively cold and fresh water in the left margin of the Gulf Stream northeast of Cape Hatteras." This water is entrained between Gulf Stream water and slope water. (Bumpus, 1972).

Ford, Longard, and Banks (1952) discuss what happens to this cold core of shelf water. They suggest that it is mixed with the waters of the Gulf Stream to alter its temperature and salinity values to those of slope water. Also, the resulting water may be discharged to the left of the stream to become a source of slope water in the upper layers (200 m). From the data they presented they found that the velocity curve showed the surface shelf water to be within the current of the Gulf Stream. Therefore, the cold water below the surface is also entrained in the current.

Rossby (1936) has shown in his wake-stream theory that the Gulf Stream can assimilate water from its right side (looking in the direction of flow) and discharge it on its left side and therefore a countercurrent should exist adjacent the left side of the Stream. Ford and Miller (1952) show evidence in support of this. They find that from west to east there is an increase in salinity in the surface layer of the Stream (+0.2 o/oo) and lower temperature (-1.5°C) which suggests absorption of water from the Sargasso Sea on the right of the Stream. They note that they found no significant change in the temperature-salinity characteristics of the slope water and hence no absorption of slope water by the Stream. Fuglister (1954) shows temperature data from 200 m which indicates a countercurrent of slope water adjacent to the northern edge of the Stream. Because the salinity and temperature of the slope water do not increase with the discharge from the Gulf Stream, Ford, Longard, and Banks (1952) state that the product of the mixture between shelf and Gulf Stream water is a necessary source of slope water.

McLellan (1957) in his study of slope water south of Nova Scotia between longitudes 65°W and 45°W found slope currents to be eastward. Fuglister (1954) has also shown, from the temperature data mentioned above, multiple currents in the Gulf Stream system from which he suggested one or more slope water currents paralleling the Gulf Stream. His data showed "strong easterly currents off the continental shelf and a countercurrent between these currents and the Gulf Stream." McLellan points out from other data that countercurrents adjacent to the Gulf Stream have not been consistently observed. He also finds offshore and onshore movements of the slope water which may be associated with meanderings in the Gulf Stream.

Whitcomb (1970) discusses hydrographic data taken in September and December 1967 over the Middle Atlantic Bight and continental slope. He discusses a counterflow west of the Gulf Stream. "East of 73°W longitude, counterflow was as shallow as 100 m and within 40 miles of the edge of the continental shelf." In a few of the sections in September and December a northeast flow below 150 m occurred between the counterflow and the continental slope. "This flow was not present in all sections and therefore may represent an eddy in the counterflow."

The closest area to the dumpsite where currents have been measured extensively is at Site D located 50 km south of the continental shelf and 175 km north of the mean axis of the Gulf Stream in 2640 m of water at 39°20'N and 70°00'W (fig. 1). Current meters have been moored at this

site at depths between 10 and 2000 m over periods of up to 3 years by Woods Hole Oceanographic Institution. It was hoped that this location would be representative of oceanic conditions with little influence from either the Gulf Stream or the continental shelf. (Thompson, 1971; Webster, 1969).

Webster (1971) studied ocean currents and kinetic energy at four different locations in the ocean away from well-defined currents, such as the Gulf Stream. He compared the results of these data with those obtained from Site D. He gathered data from WSW and NNE of Bermuda, the Bay of Biscay, and the Mediterranean. With the exception of NNE of Bermuda the current speeds were within a factor of 1.5 of Site D and the kinetic energy within a factor of 2. He postulates that the reason the region NNE of Bermuda was different (current speed and kinetic energy were found to be higher) was that this region may have been under the influence of a Gulf Stream meander. Even though these regions were very different geographically and subject to different local effects, Webster states reasons why the data from each station are within a narrow range. He suggests that the "narrow range of ocean current energy may indicate a saturation mechanism that prevents energy from exceeding a natural limit or energy may be kept above some natural level by a long time-constant for energy dispersion and dissipation." He further states that the results from the data suggest "that global effects are important in the process of generation of oceanic energy."

Site D is approximately 110 nmi northeast of Deepwater Dumpsite 106 (fig. 1). Below 200 m the water in the dumpsite is representative of near oceanic water. Perhaps the current speeds and kinetic energy are similar to those at Site D. The average currents at Site D were found to be westward with decreasing amplitude with depth (Webster, 1969; Fofonoff and Webster, 1971). The mean speed profile was found to show regularity in amplitude and the mean velocity profile showed regularity in direction. Webster says that the net flow is probably part of the westward flow in the slope water region. The apparent net transport to the west was found to be $0.072 \times 10^6 \text{ m}^3/\text{sec}/\text{km}$. The current velocities ranged from around 40 cm/sec at the surface to 5 cm/sec at 2000 m. They did not vary at any one depth by more than a factor of 6.

It is interesting to note that Webster (1969) found that the temperature-salinity data measured during the study showed the dominant water type to be slightly fresher than slope water (as defined by McLellan, 1957), and that there are intrusions of Labrador Coastal water (as defined by Worthington, 1964). He notes that "such water mass characteristics are not clearly consistent with a persistent westward flow in the region of Site D." Fofonoff and Webster (1971) found current directions at all depths for Site D to be westward and parallel to the bottom topography.

In the dumpsite region, the Oceanographer of the Navy (1972) reports a mean surface current speed of about 25 cm/sec. Current direction was reported to be either east-northeast or south-southwest. They reported no bottom current velocities.

Volkman (1962) measured deep currents east of the dumpsite and south of 40°N to the northern edge of the Gulf Stream. He found westward currents that measured 10 to 22 cm/sec at 2000 m. He postulates that this flow may be a series of eddies or transients with a net flow along the coast and some of this water may be recirculated by the Gulf Stream. Zimmerman (1971) also found currents in this area which had a measured flow of 15 cm/sec. He placed current meters 2m off the bottom in depths from 2900 to 5000 m on the continental rise. The flow was in a west-southwest direction along the depth contours. The velocities were found to be high enough to erode and transport sediment. He found complex interactions between the Gulf Stream and the bottom contour currents. A Gulf Stream meander was reflected in his current meter data by a change in direction at some of the locations and a decrease in velocity in others. Barrett (1965) measured subsurface currents off Cape Hatteras. He found a continuous southward current along the continental slope from several hundred meters below the surface to 2500 m.

Thompson (1971) suggests that the major part of deep currents (below 500 m) may be topographic Rossby waves driven by eddies in the Gulf Stream. Rhines (1971) presents evidence that topographic waves over 40 km are indeed present.

Gulf Stream Water

To the east of the slope water region is the Gulf Stream, (fig. 2), a moving current with core velocities 200 cm/sec or greater (Von Arx, 1962). The Gulf Stream, a continuation of the Florida Current (a northward-flowing current which extends from Florida to Cape Hatteras), flows northeastward from the continental slope off Cape Hatteras to east of the Grand Banks. Throughout this region the Gulf Stream meanders at times. When these meanders become very large they break away from the Gulf Stream and become eddies or rings (Saunders, 1971). Cyclonic eddies form south of the Gulf Stream; in their formation slope water is entrained. These then become cold water eddies which move in a southwestward direction at around 10 cm/sec (Fuglister, 1971; Saunders, 1971). Anticyclonic or warm water eddies form north of the Gulf Stream. These entrain Sargasso Sea water during formation. These eddies drift into the slope water and then migrate in a southwestward direction through the slope water until they either dissipate or join the Gulf Stream in the vicinity of Cape Hatteras. (Fisher, 1973; Saunders, 1971).

SEAWATER PROPERTIES

Few hydrographic measurements have been taken at Deepwater Dumpsite 106. Much of the data taken has been gathered by the United States Coast Guard in a series of International Commission for Northwest Atlantic Fisheries (ICNAF) cruises. These were conducted for most seasons over the Middle Atlantic Bight area and beyond the continental slope into the dumpsite region. The parameters measured were temperature, salinity, and oxygen concentrations for all cruises. Chemical measurements also were made on several of the cruises. Some of these data are presented by

Whitcomb (1970). Other data from the dumpsite area are the Marine Resources Monitoring, Assessment, and Prediction (MARMAP) data. The ICNAF and MARMAP data have been discussed and are available from the author. Monthly summaries from Marsden Square 116, subsquares 81, 82 and 91 are discussed below.

The water masses in and surrounding DWD 106 are best identified by temperature-salinity relations. Abrupt changes in temperature and salinity can occur between shelf and slope water. Shelf water is always fresher than slope water and is much colder in the winter months. During the warming period, peak surface temperature of shelf water exceeds that of slope water. Only during periods of warming and cooling does the horizontal temperature gradient between the two water masses become less marked. The water masses are then best distinguished by salinity differences.

The upper 100 to 150 m of water in the dumpsite area are known to be highly variable throughout the year. The shelf/slope front can lie to the left, right, or pass through the dumpsite area. Through the winter and spring the shelf/slope front usually is found anywhere from the shelf break (200 m isobath) to 80 miles south and east of the 200-m contour. During summer, the front occupies the position near the 200-m isobath. In autumn the front occupies the position near the 200-m isobath. In autumn the front usually lies to the north and west of the shelf break (Marcus, 1973). The differences between slope and Gulf Stream water in autumn are less marked but are distinguishable by slope water being slightly fresher and cooler.

Marsden Square 116 and subsquares 81, 82, and 91 are shown in figure 7. The average surface temperature, salinity, and oxygen data of each subsquare were plotted for each month. Some of the values represent only one or two observations and may not be indicative of normal conditions (fig. 8).

Temperature (figs. 8a, 9, 10, 11)

All surface temperature values followed the same pattern, with lowest temperatures in March and highest temperatures in August. The range of temperature in subsquare 91 was less than that of the other two from February through June (fig. 8a). Surface temperatures ranged between 5° and 25°C, the lowest being 5°C in February in subsquare 82. The ranges for each subsquare are shown in table 2.

Table 2.--Average surface temperature ranges and month of minimum and maximum temperatures for subsquares 81, 82, and 91 in Marsden Square 116

Subsquare	Month of minimum temperature	Average surface temperature range (°C)	Month of maximum temperature
81	January	7.8 - 24.9	August
82	February	5.2 - 25.0	August
91	March	5.4 - 24.5	August

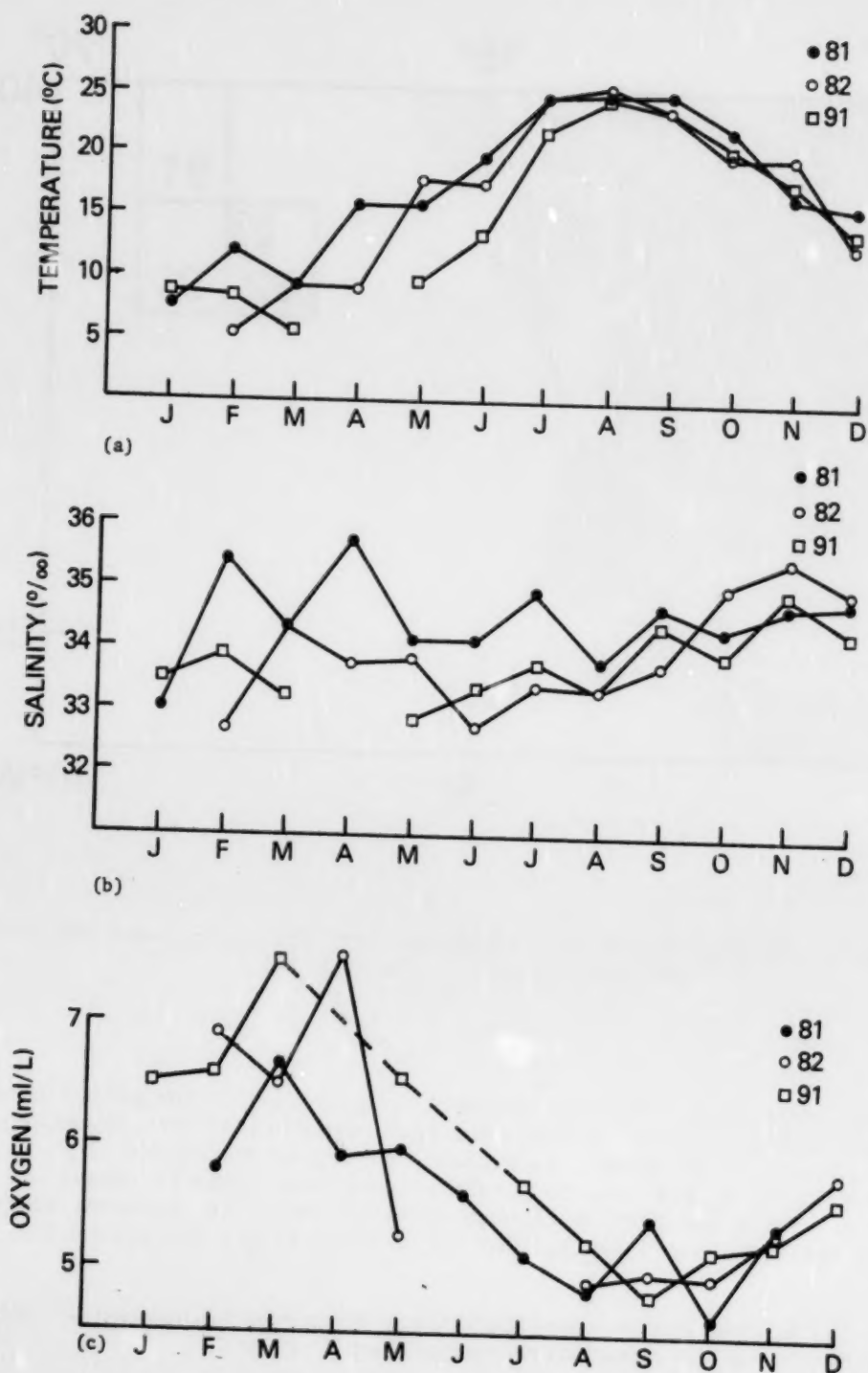


Figure 8.--Average monthly sea surface temperature, salinity, and oxygen for Marsden Square 116, subsquares 81, 82, and 83.

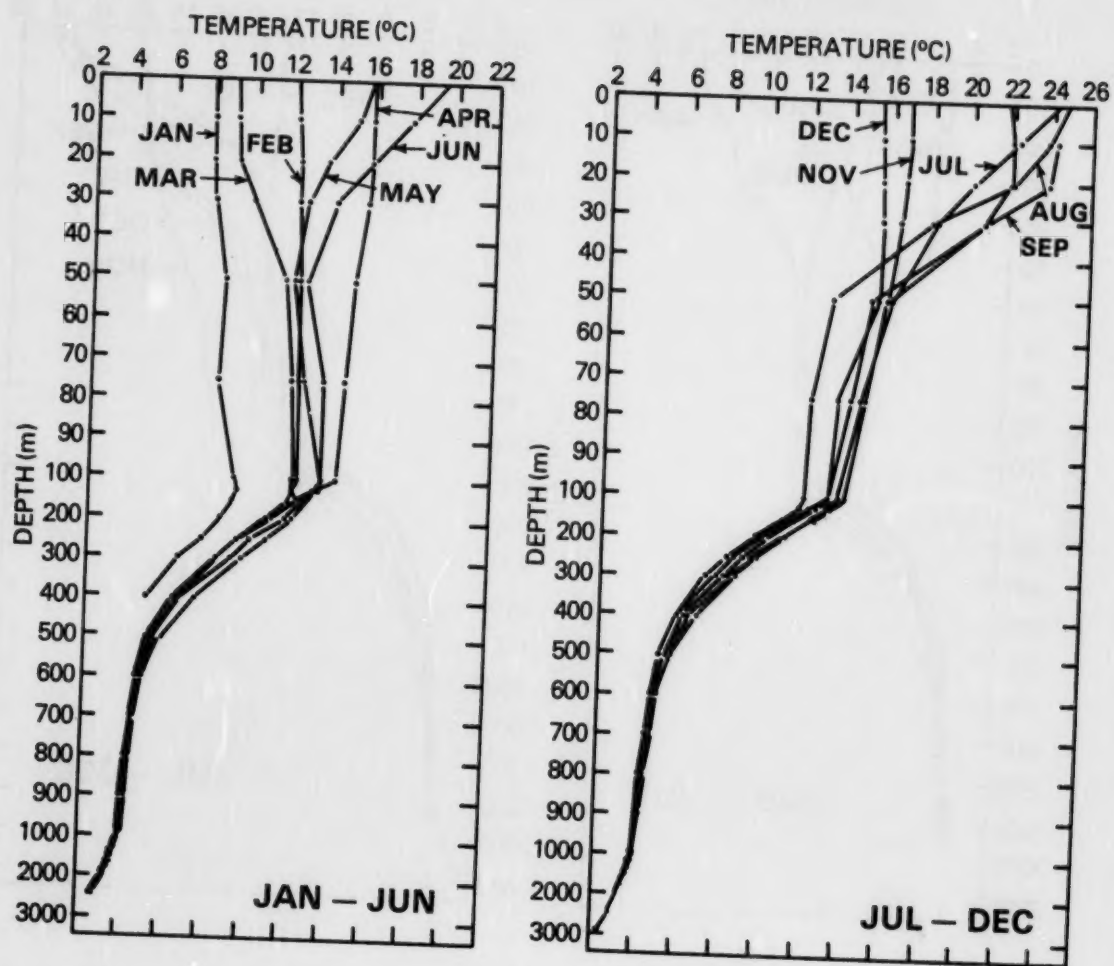


Figure 9.--Temperature versus depth, monthly averages for Marsden Square 116 subsquare 81.

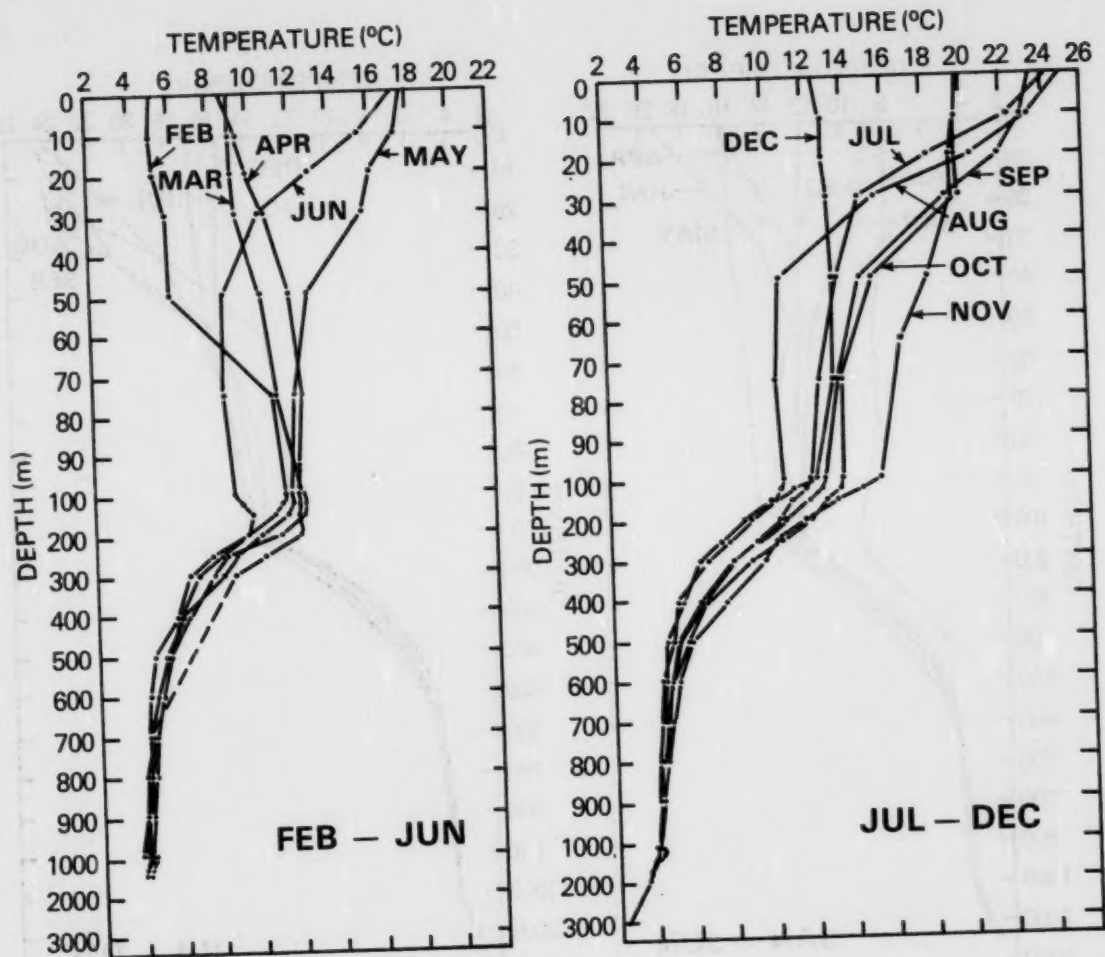


Figure 10.--Temperature versus depth, monthly averages for Marsden Square 116 subsquare 82.

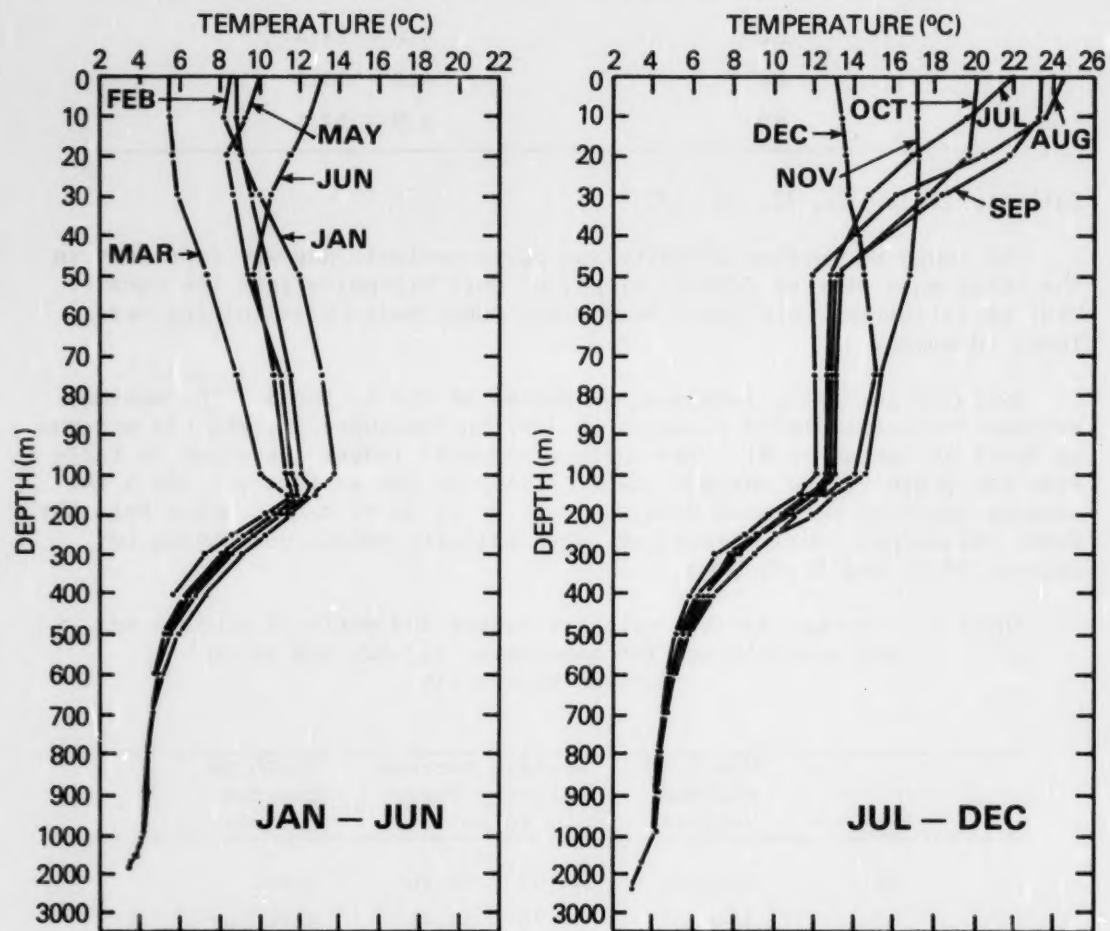


Figure 11.--Temperature versus depth, monthly averages for Marsden Square 116 subsquare 91.

Table 3.--Average temperature ranges between 100 and 500 m for subsquares 81, 82, and 91 in Marsden Square 116

Subsquare	Average temperature ranges(°C) from 100 to 500 m
81	5.0 - 14.4
82	4.8 - 15.8
91	5.0 - 14.6

Salinity (figs. 8b, 12, 13, 14)

The range of surface salinity was quite variable and was dependent on the water mass present (shelf, slope, or Gulf Stream) within the square. Minimum salinities were found in May and June; maximum salinities were found in August.

Salinity generally increased to depths of 100 to 150 m. The minimum average surface salinity occurred in June in subsquare 82, and the maximum in April in subsquare 81. The surface salinity ranges are shown in table 4. From the depth of the maximum salinity (100 to 150 m) to about 400 m the average salinity decreased from about 35.75 to 34.95 o/oo. Below this the water column was nearly isohaline, with salinity values decreasing to between 34.90 and 35.05 o/oo.

Table 4.--Average surface salinity ranges and month of minimum and maximum salinity for subsquares 81, 82, and 91 in Marsden Square 116

Subsquare	Month of minimum salinity	Average surface salinity range (o/oo)	Month of maximum salinity
81	January	33.05 - 35.75	April
82	June	32.70 - 35.45	November
91	May	32.85 - 34.90	November

Oxygen (figs. 8c, 15, 16, 17)

Surface oxygen values generally followed the same pattern with maximum values in winter (March) and minimum values in summer (September). The range of surface oxygen values for subsquare 91 generally was higher than for the other two subsquares from February through July. The average surface oxygen concentration ranged from 4.6 ml/L in October (subsquare 81) to 7.5 ml/L in March (subsquare 91). Generally, the surface values were above 5.5 ml/L from December through June and below this value from July through November. Oxygen generally decreased with depth to approximately

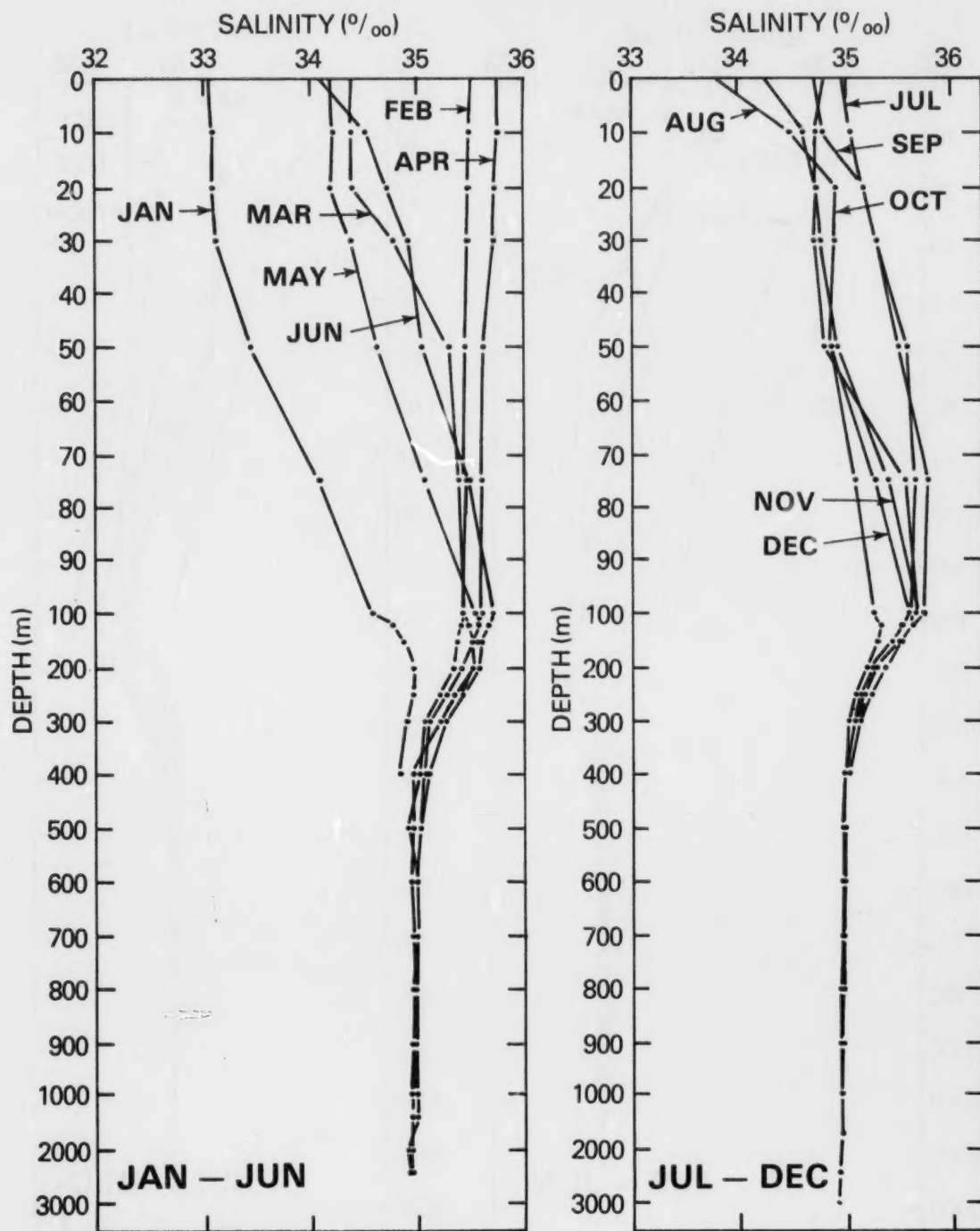


Figure 12.--Salinity versus depth, monthly averages for Marsden Square 116 subsquare 81.

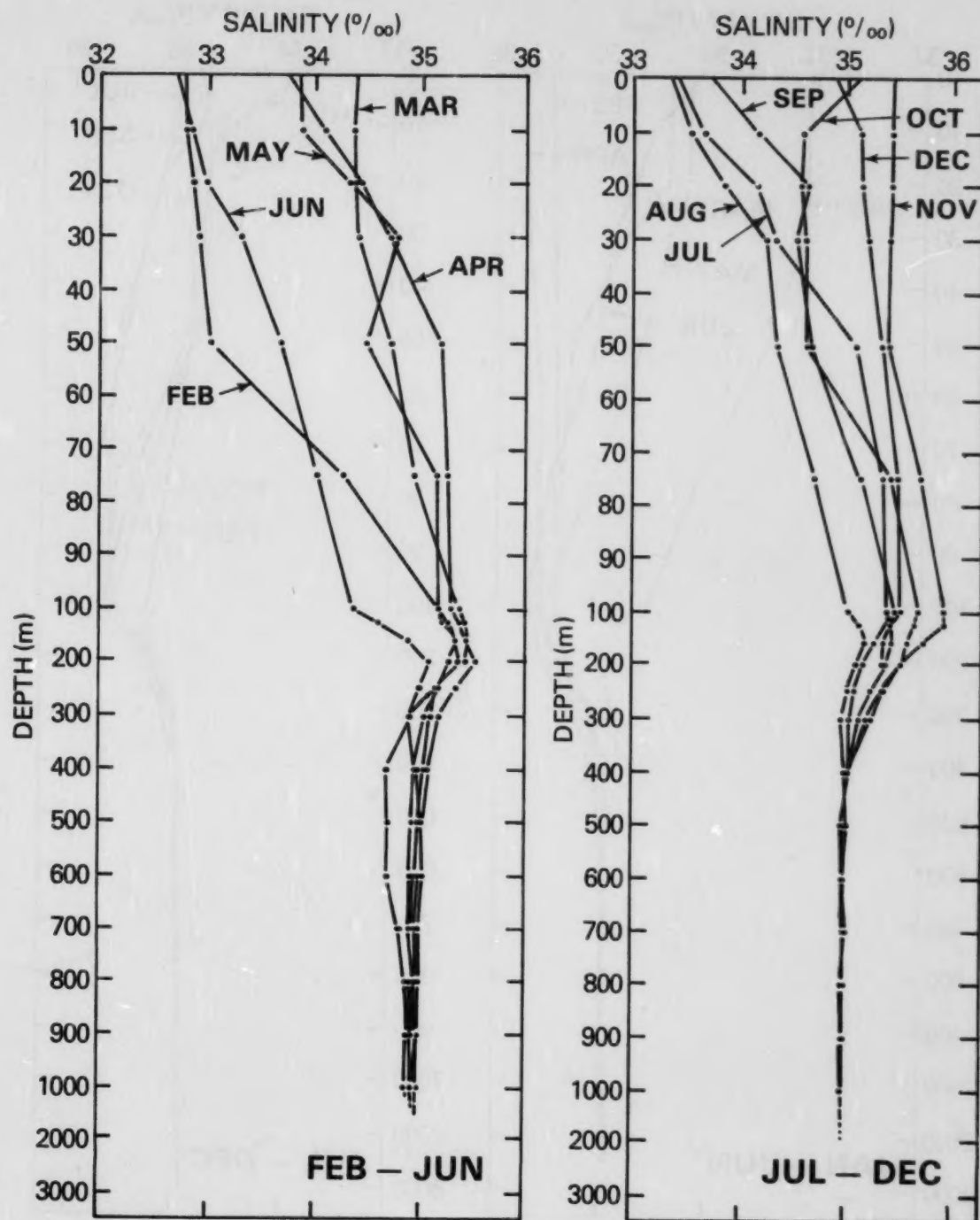


Figure 13.--Salinity versus depth, monthly averages for Marsden Square 116 subsquare 82.

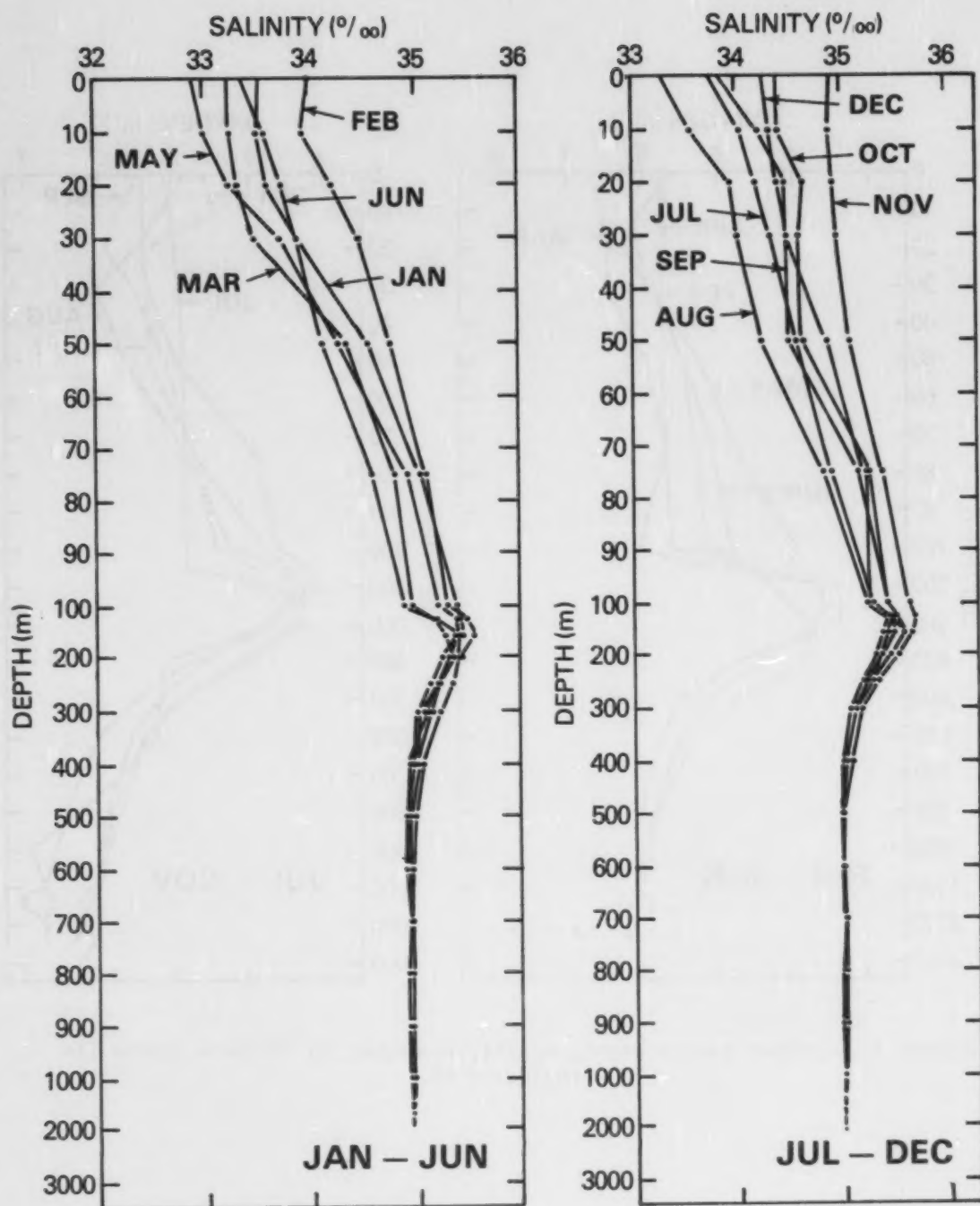


Figure 14.--Salinity versus depth, monthly averages for Marsden Square 116 subsquare 91.

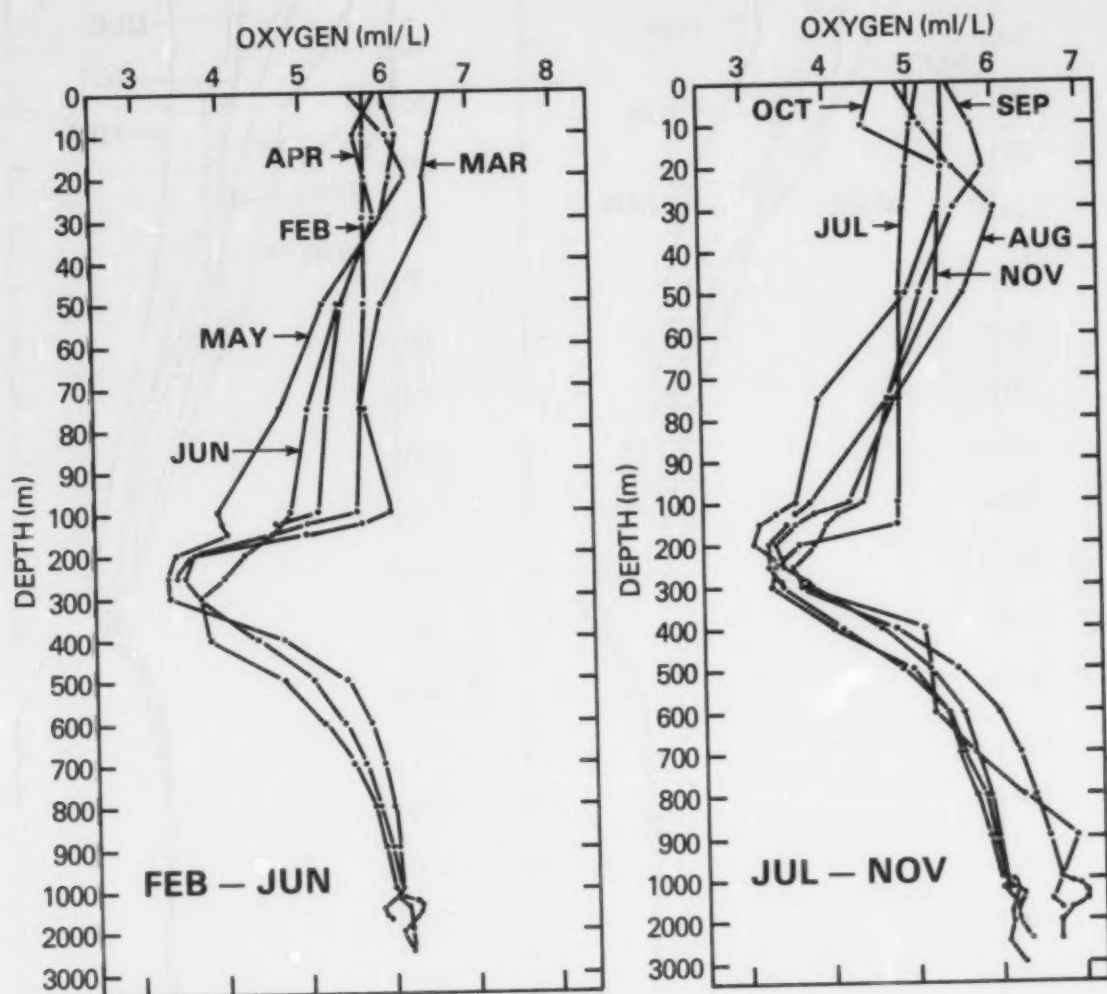


Figure 15.--Oxygen versus depth, monthly averages for Marsden Square 116 subsquare 81.

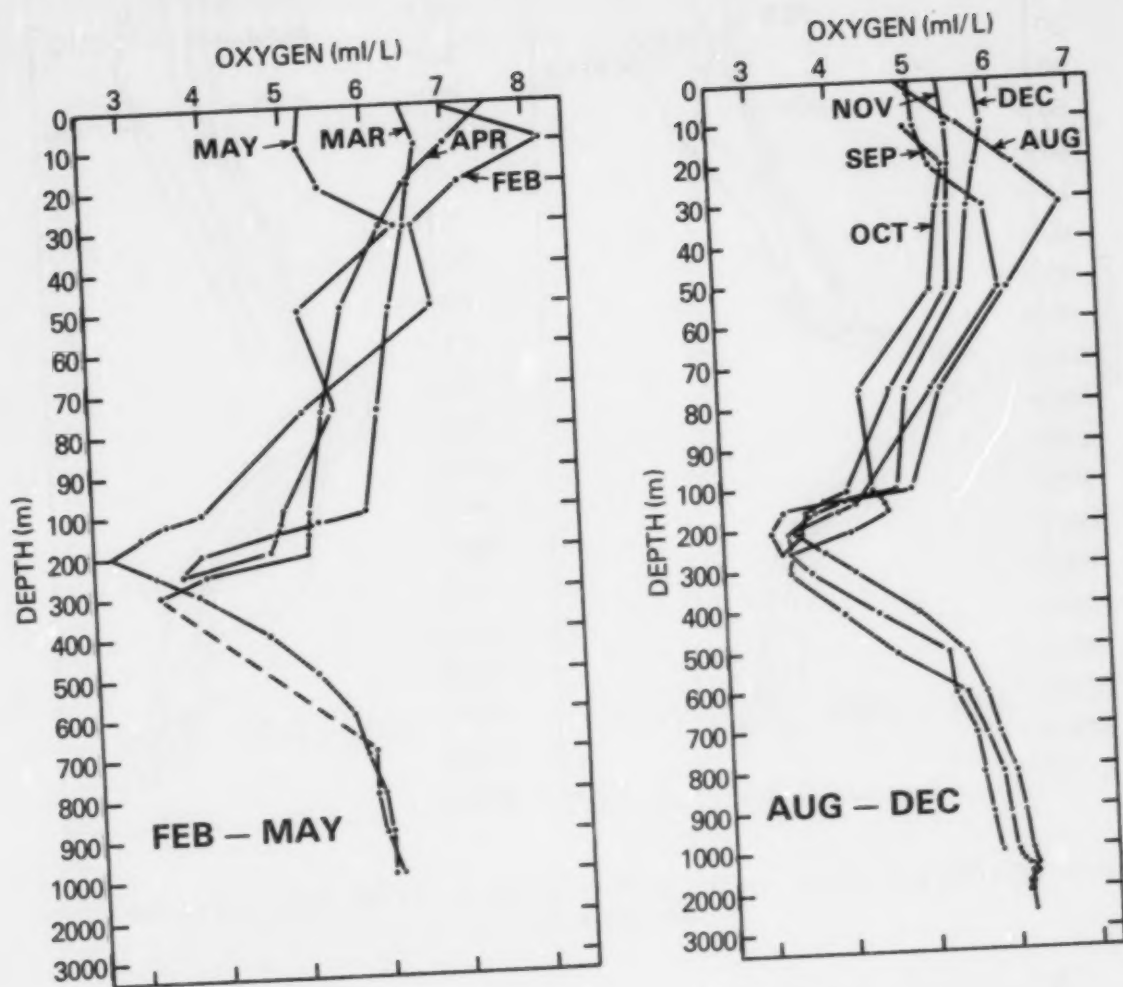


Figure 16.--Oxygen versus depth, monthly averages for Marsden Square 116 subsquare 82.

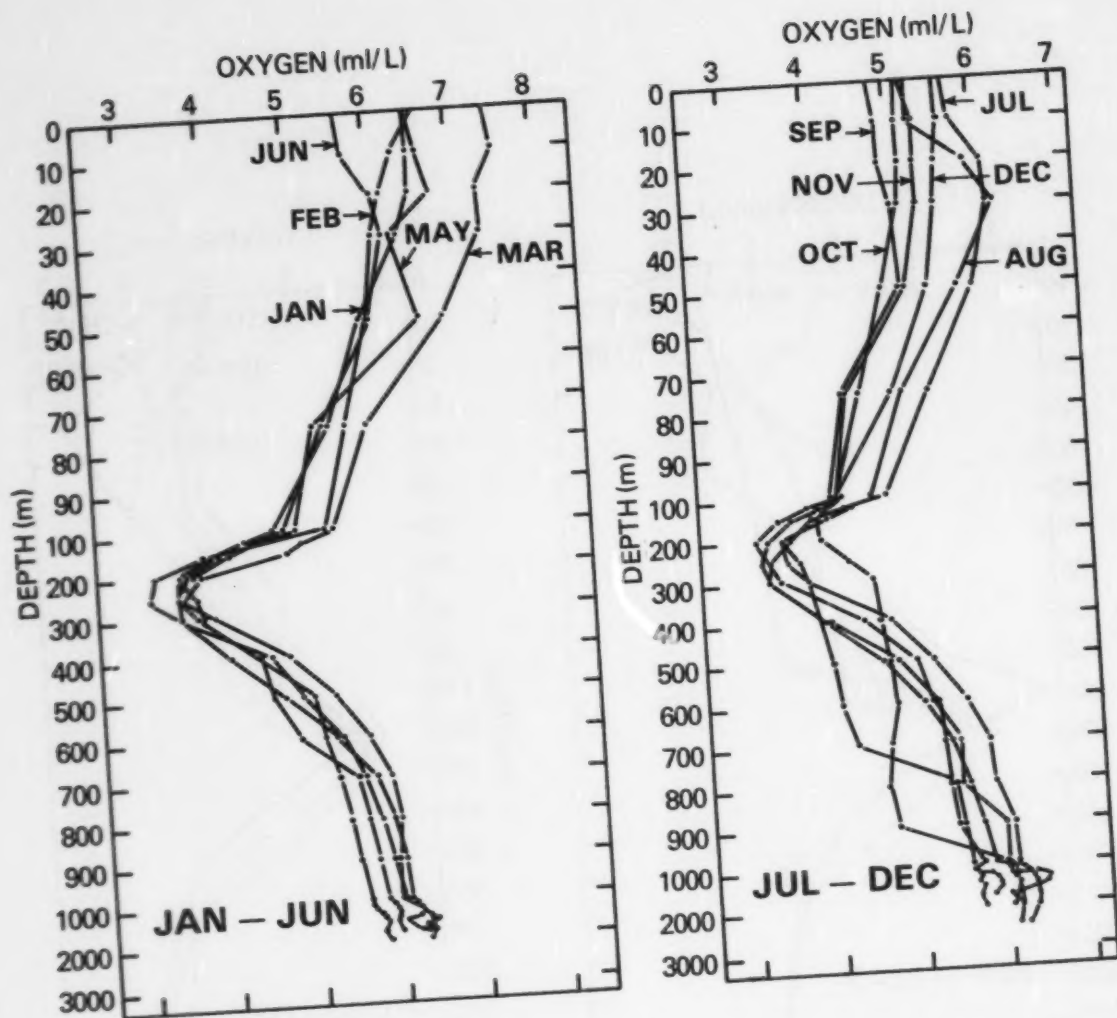


Figure 17.--Oxygen versus depth, monthly averages for Marsden Square 116 subsquare 91.

200 to 300 m. In several months a subsurface (30 m) maximum developed and was present in all three subsquares in March, August, and September. It varied during the other months.

The oxygen minimum zone is between 200 and 300 m and oxygen values generally are between 3.0 and 3.8 ml/L. From the minimum zone to about 500 m the average amount of dissolved oxygen increased to no greater than 5.5 ml/l. Between 500 and 1000 m the values increased to about 6 ml/L. Two months showed values higher than 6.5 ml/L at 1000 m (September and October for subsquare 81). Below 1000 m there was another oxygen maximum which ranged from greater than 5.5 ml/L to greater than 6.5 ml/L. In September in subsquare 81 this average maximum was greater than 7 ml/L.

Temperature-salinity (figs. 18, 19, 20)

Monthly averages for temperature versus salinity were plotted. The upper 100-150 m varied considerably throughout the year. In January, February, and March both temperature and salinity increased with depth to about 125 to 150 m. Temperature increased from 5°C to about 12°C; salinity increased from less than 33 o/oo to greater than 35 o/oo. April values were recorded for only subsquares 81 and 82 and were representative of only one observation for each depth in subsquare 81. In subsquare 81 April followed the same pattern as the winter described above. The upper 100 m for subsquare 82 showed salinities greater than 35.5 o/oo between temperatures of 14.5° and 16°C. During June, in all three subsquares, in the upper 50 m temperature decreased and salinity increased with depth. Below this to about 100 to 150 m temperature and salinity both increased. The range was quite different for the subsquares during this month and are listed in table 5.

Table 5.--Average temperature-salinity ranges between 0 m to 50 m and 50 m to 100 m for subsquares 81, 82, and 91 in Marsden Square 116

Subsquare	0 m T(°C)	50 m S(o/oo)	50 m T(°C)	100 m S(o/oo)
81	12.6 - 19.5	34.05 - 35.05	12.6 - 13.7	35.05 - 35.65
82	8.5 - 17.4	32.70 - 33.20	8.5 - 9.2	33.20 - 35.00
91	13.0 - 9.8	33.25 - 34.15	9.8 - 11.5	33.15 - 35.40

The lower salinities from March through June were probably a result of spring land runoff. During the remainder of the year (July through December) in the upper 50 m temperature decreased with depth from 25° to 11°C. There was a slight increase in salinity with depth for each month. The range of salinity for this time period is from 33 to 36 o/oo. Maximum surface temperatures were in August; maximum salinities appeared in November, except for subsquare 81 (the most seaward) where maximum salinity was in April. Above 150 m both temperature and salinity values were higher for July than for June and August. For depths below 100 to 150 m all temperature-

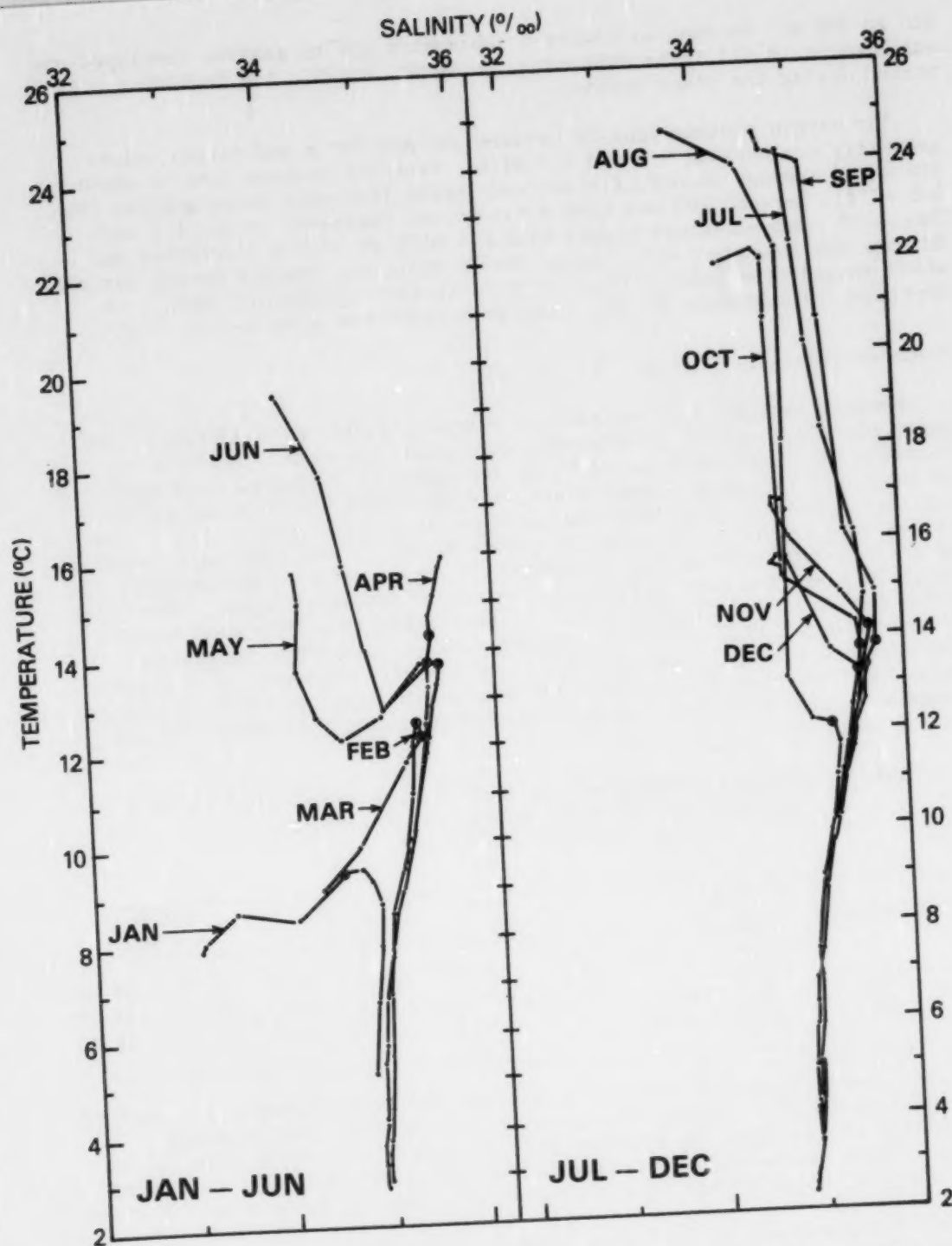


Figure 18.--Temperature-salinity relations, monthly averages for Marsden Square 116 subsquare 81.

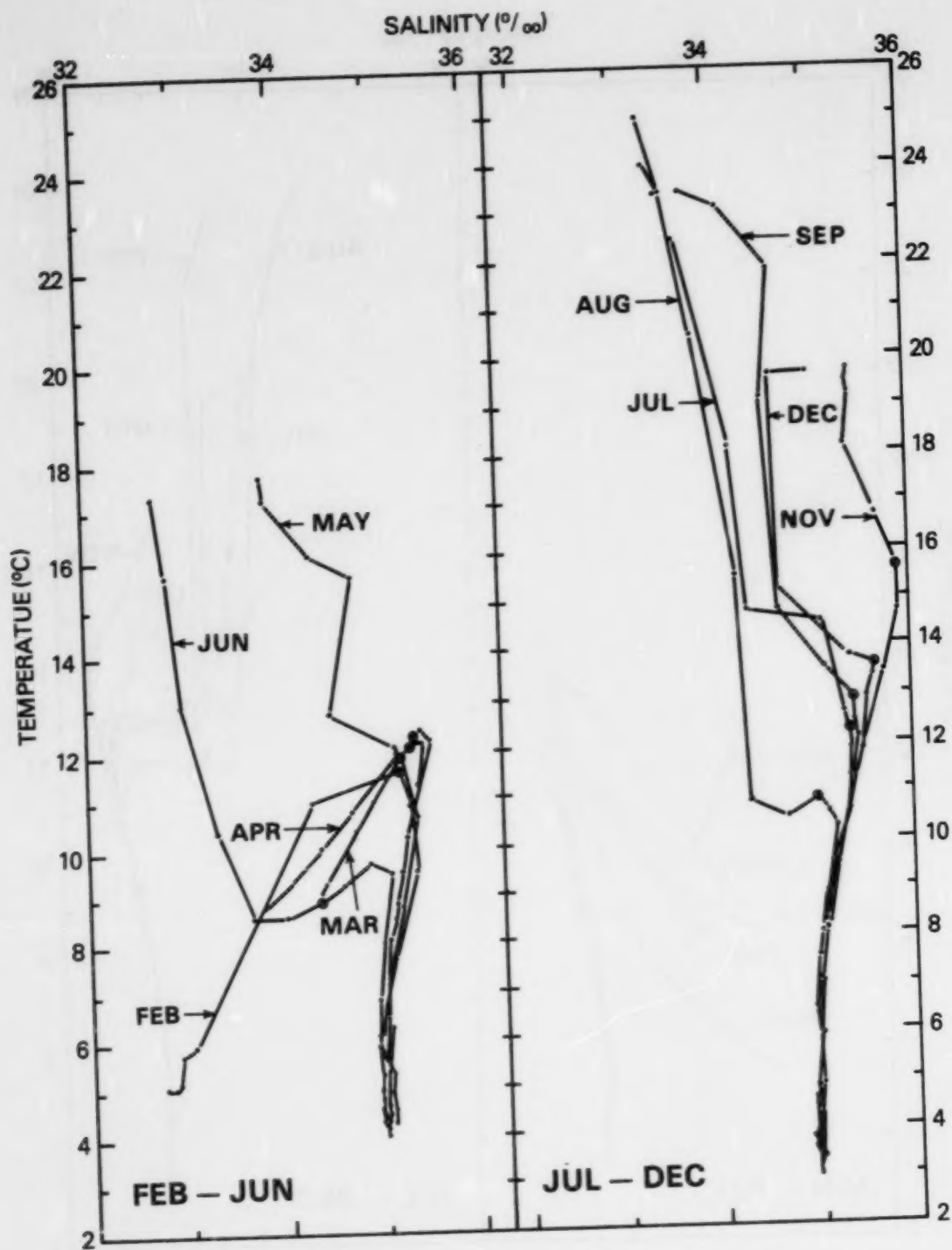


Figure 19.--Temperature-salinity relations, monthly averages for Marsden Square 116 subsquare 82

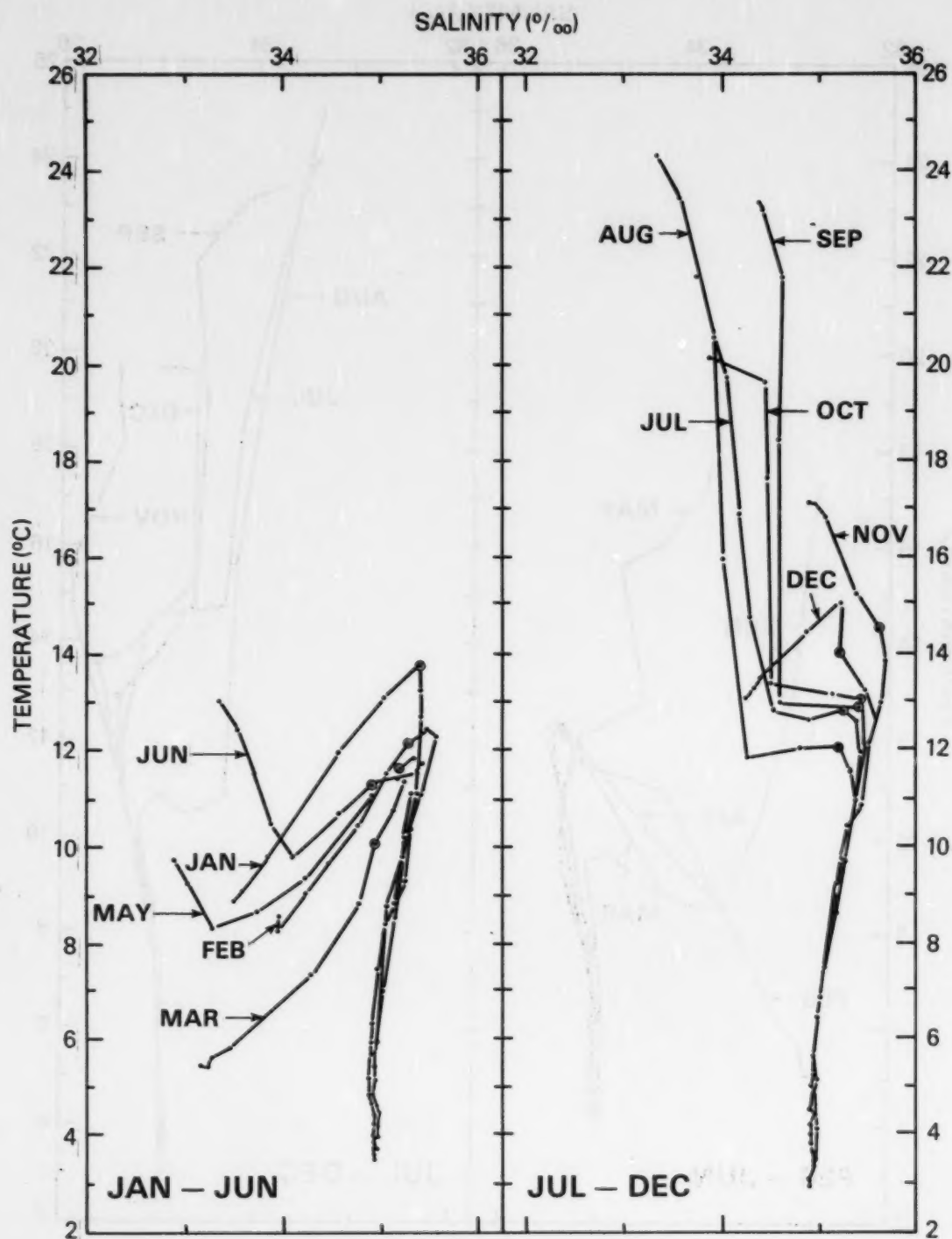


Figure 20.--Temperature-salinity relations, monthly averages for Marsden Square 116 subsquare 91.

salinity curves converge to a salinity of about 35.5 o/oo for temperatures between 11° and 14.5°C. For temperatures less than 7°C the salinity range was from 34.9 to 35.05 o/oo. In the temperature range 7° to 11°C the salinity range was from 35.05 to 35.5 o/oo (11°C was the value at approximately 200 m).

Oxygen-sigma-t (fig. 21)

The monthly average values of dissolved oxygen were plotted against the average sigma-t values to determine if a relationship exists to distinguish water masses in the area of Deepwater Dumpsite 106. As in the temperature-salinity diagrams, the upper 100 m of the oxygen-density diagrams also varied with the season. Both the sigma-t values and the oxygen values showed an increase in the winter and a decrease in the summer for all 3 subsquares. Maximum oxygen and sigma-t values were in March. At 100 m nearly all sigma-t values were between 26.5 and 27.0 and were concentrated near 26.75. The seasonal range of oxygen for the 100-m depth was observed to be as low as 3.5 ml/L or as great as 6 ml/L; 66 percent of the oxygen values were between 4 ml/L and 5 ml/L.

The oxygen minimum layer (200 to 300 m) had a sigma-t value of approximately 27.25. At greater depths the amount of dissolved oxygen increased--to > 6 ml/L below 1500 m; sigma-t increased to about 27.85. Below 1500 m the amount of dissolved oxygen might decrease slightly and then increase again. This was observed for sigma-t values between 27.75 and 27.85.

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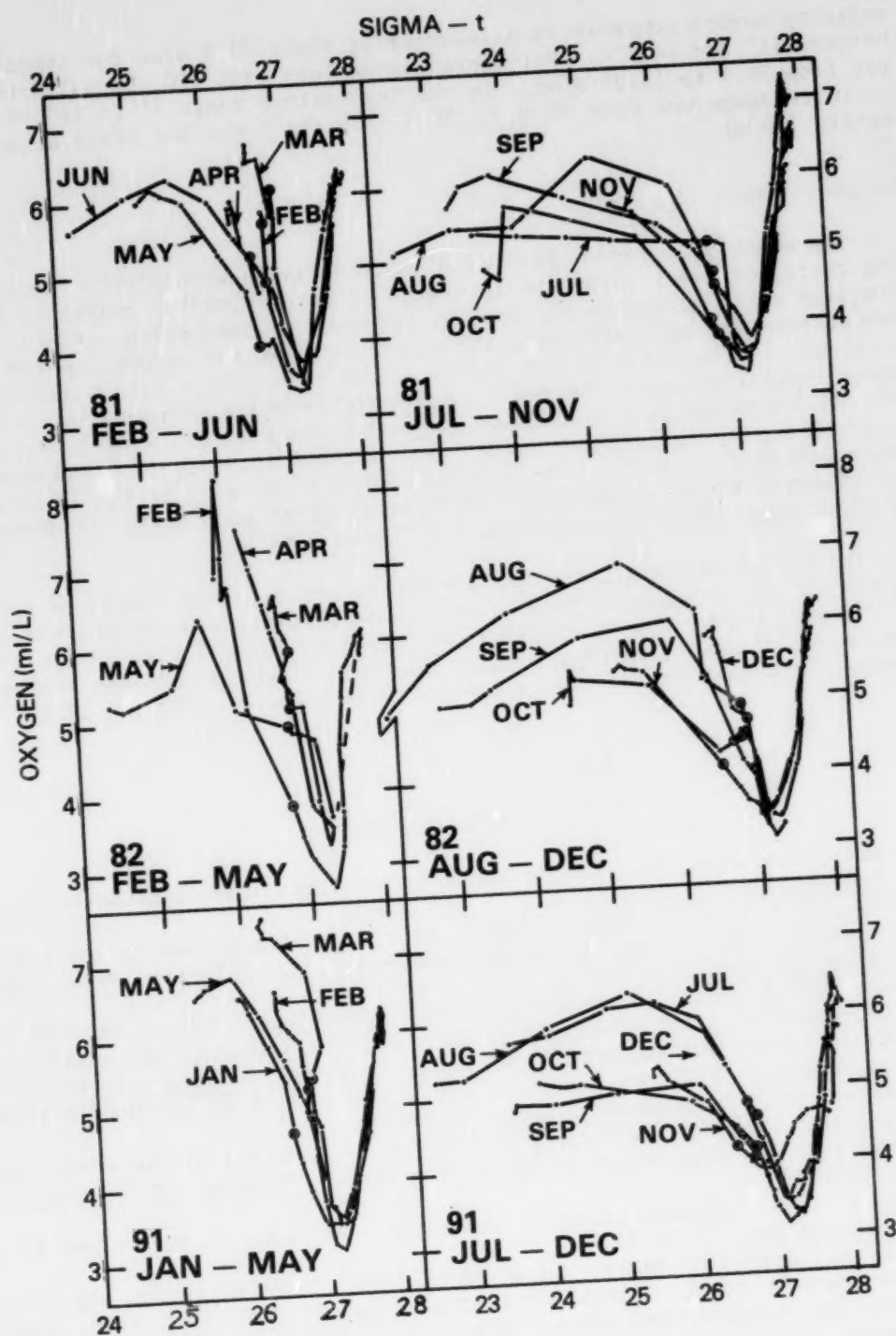


Figure 21.--Oxygen-density relations, monthly averages for Marsden Square 116 subsquares 81 (top), 82 (center), and 91 (bottom).

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PHYSICAL OCEANOGRAPHIC OBSERVATIONS AT
DEEPWATER DUMPSITE 106 -- MAY 1974

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Narragansett, R.I.

INTRODUCTION

A cruise to study the water in and near Deepwater Dumpsite 106 (DWD 106) was made by the NOAA ship Albatross IV from May 9 through May 24, 1974. Physical, chemical, and biological sampling were completed. This discussion is concerned with only the physical data and some chemical data. Twenty-three stations were occupied during the cruise (fig. 1). Physical and chemical data were collected at all stations except No. 3. A total of 99 expendable bathythermographs (XBTs) were dropped to depths of 1800 m. XBT drops were made at the start and finish of each station and between stations. At each station a 9040 STD (salinity, temperature, depth recorder) was lowered to depths of 1500 m to record temperature and salinity. A rosette sampler was attached to the STD to obtain supporting chemical data. Where depths exceeded 1500 m, hydrocasts were made from 1300 m to near the bottom to collect temperature, salinity, oxygen, and nutrient data. Temperature was measured by reversing thermometers, salinity on board by an inductive salinometer, and oxygen by the Winkler method. For a complete description of operations at each station see the Cruise Report for the Albatross IV by M. C. Ingham. The data are available at the National Oceanographic Data Center, National Oceanic and Atmospheric Administration, Washington, D.C. 20235.

SEAWATER PROPERTIES

Temperature (figs. 2, 3, 4-11)

Sea surface temperature was found to increase from north to south (fig. 2). Temperature values over or near the continental shelf ranged from 11° to 14°C. Offshore they increased to 21°C. A strong thermocline, in which temperatures decreased from 21° to 14°C was found in the upper 100 m off of the continental shelf at most stations. From 600 m to the bottom (depths to 2800 m) the temperature decreased from 5° to 2.3°C (figs. 3-10).

In the upper 100 m there were thin layers of water. These appeared to be intrusions of shelf water into slope water, and resulted in temperature inversions. They are best seen on data plots for stations 7 and 8 and stations 17 and 18 between depths of approximately 50 and 75 m (figs. 5, 10). Temperature inversions are not uncommon in this region. They were observed at depths of about 75 m at several stations (figs. 3-10).

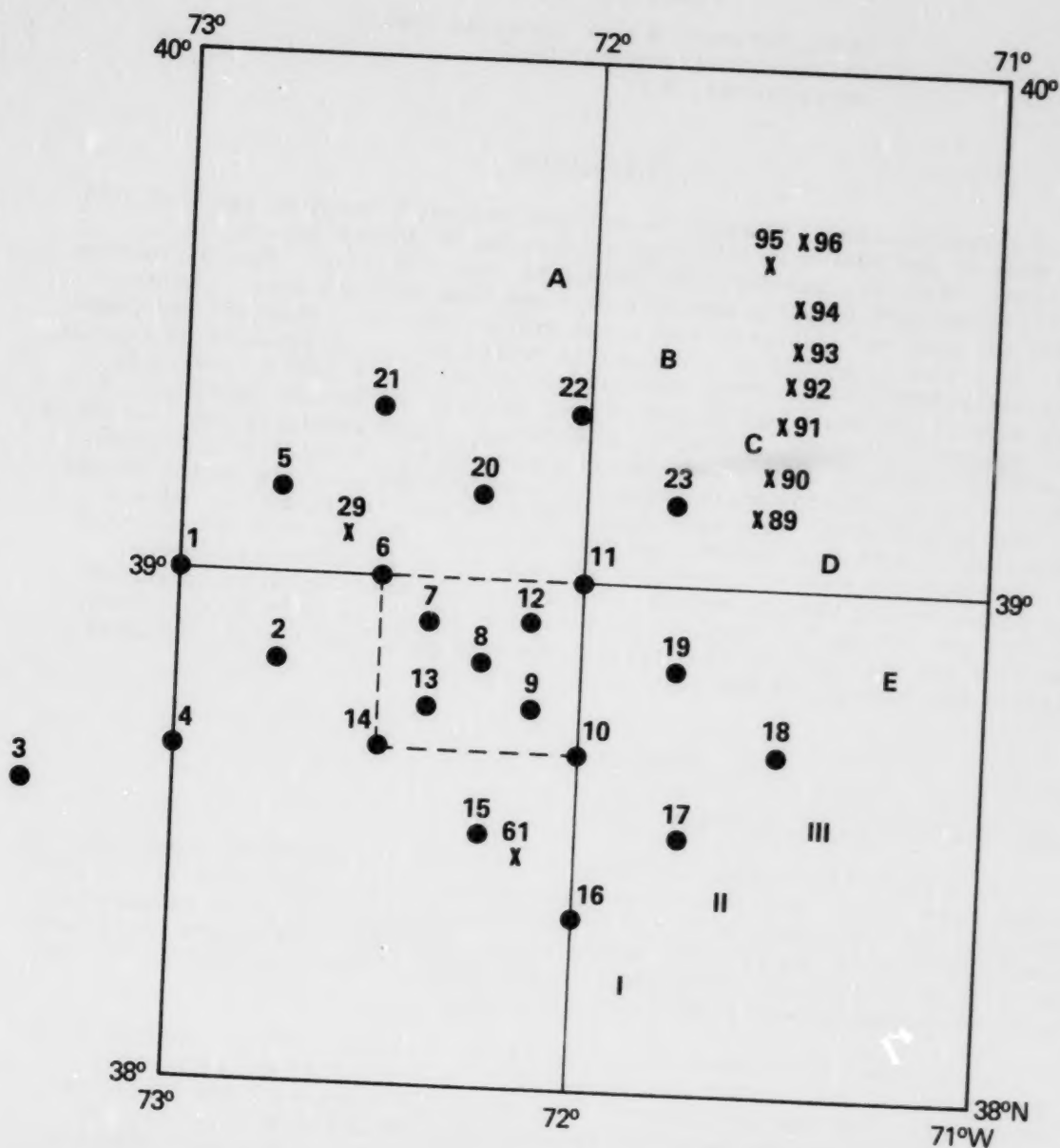


Figure 1.--Station positions for Albatross IV cruise of May 1974. Numbers indicate order of occupation. • = station positions; X = XBT stations used; dashed lines indicate dumpsite region; A, B, C, D, E and I, II, III designate section plots.

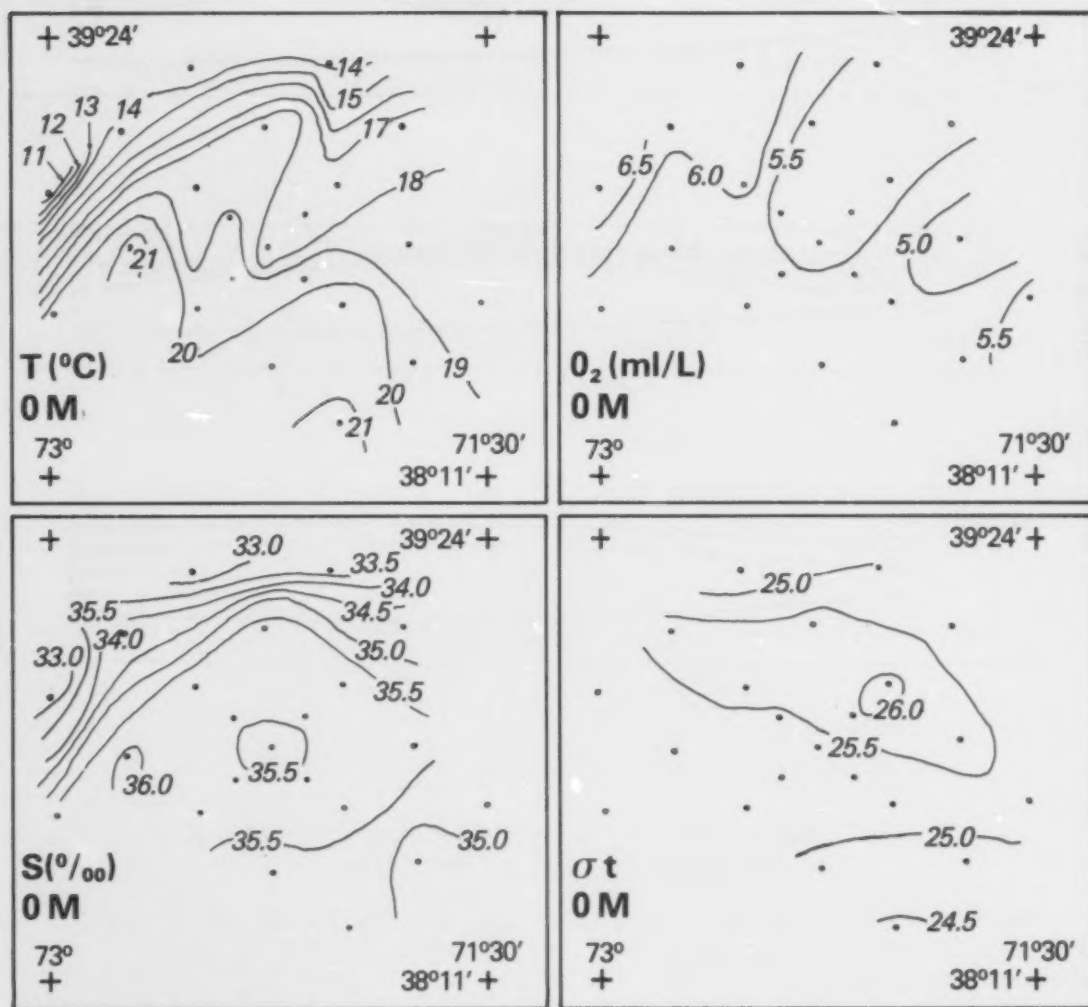


Figure 2.--Temperature, salinity, oxygen, and sigma-t at the surface.
Albatross IV cruise May 1974.

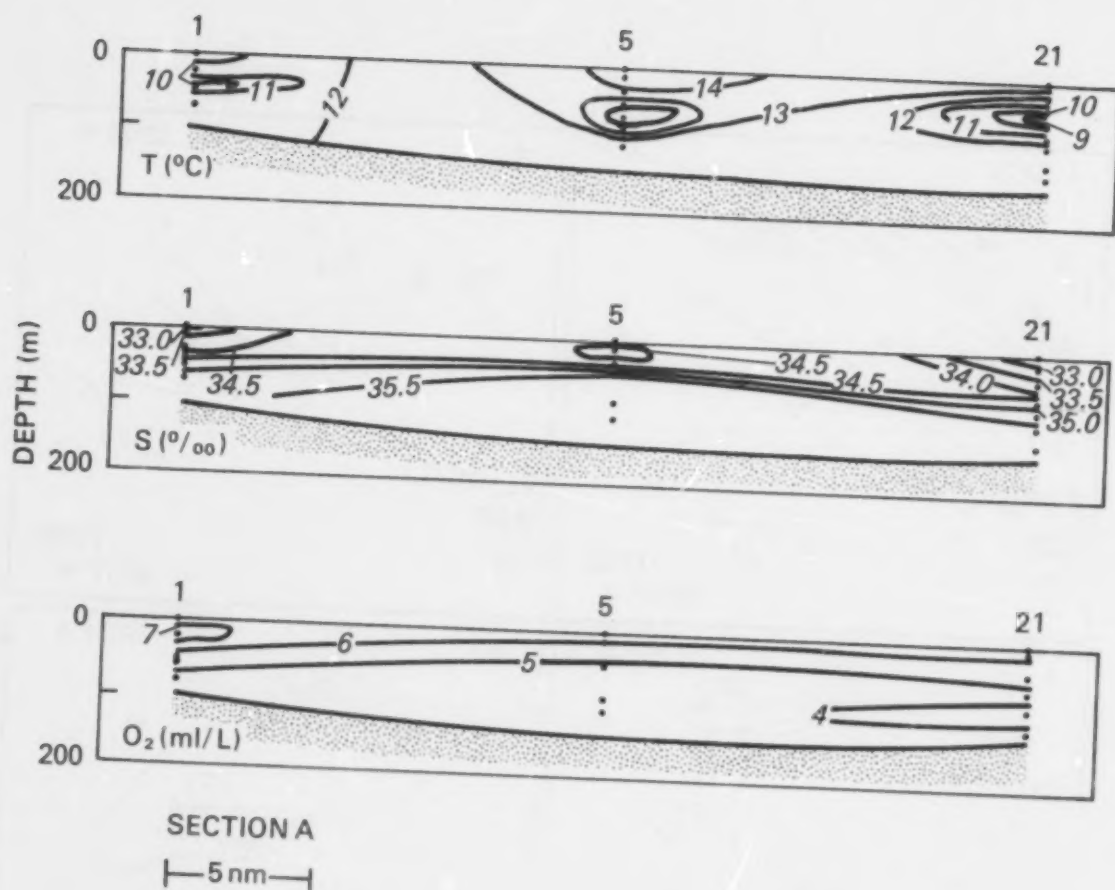


Figure 3.--Temperature, salinity, and oxygen. Section A.
Albatross IV cruise. May 1974

The water column at stations 11, 12, 19, 20, and 23 between 50 and 350 m was found to be warmer than at corresponding depths for other observed stations (figs. 6, 8). The temperature in this depth range decreased from 14.9° to 14.4°C , a nearly isothermal layer. This warm layer extended to 350 m at stations 11 and 23 and to 250 m at the other named stations. It should be noted here that the National Environmental Satellite Service (NESS) data showed a warm eddy to the north of station 23 (Appendix A). A plot of XBT data (fig. 11) shows 15°C water at 200 m at XBT Station 91, and at XBT Stations 84 and 90 between 50 and 350 m is the 14°C layer that was found in the STD data. At the time these STD data were collected the warm eddy was beginning to dissipate (May 22-23, 1974) and was gone from the satellite data by May 28, 1974 (personal communication, E. P. Daghir of NESS). Apparently this warm layer was a part of that eddy. The temperature-salinity characteristics of this water will be discussed below. Lying on top of the warm eddy was a thin layer of water that was more characteristic of slope water than Gulf Stream water.

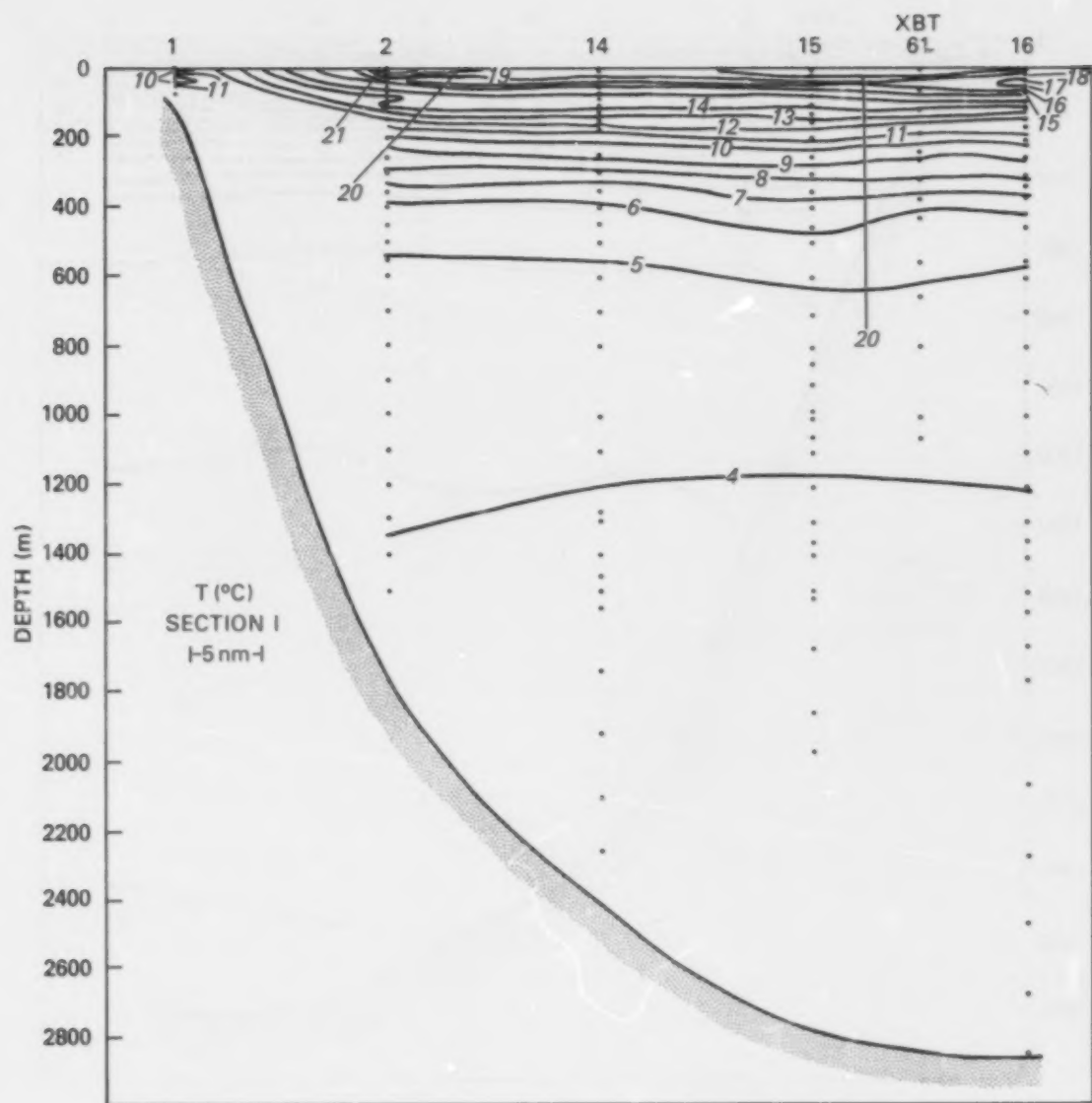


Figure 4.--Temperature, section I. Albatross IV cruise May 1974.

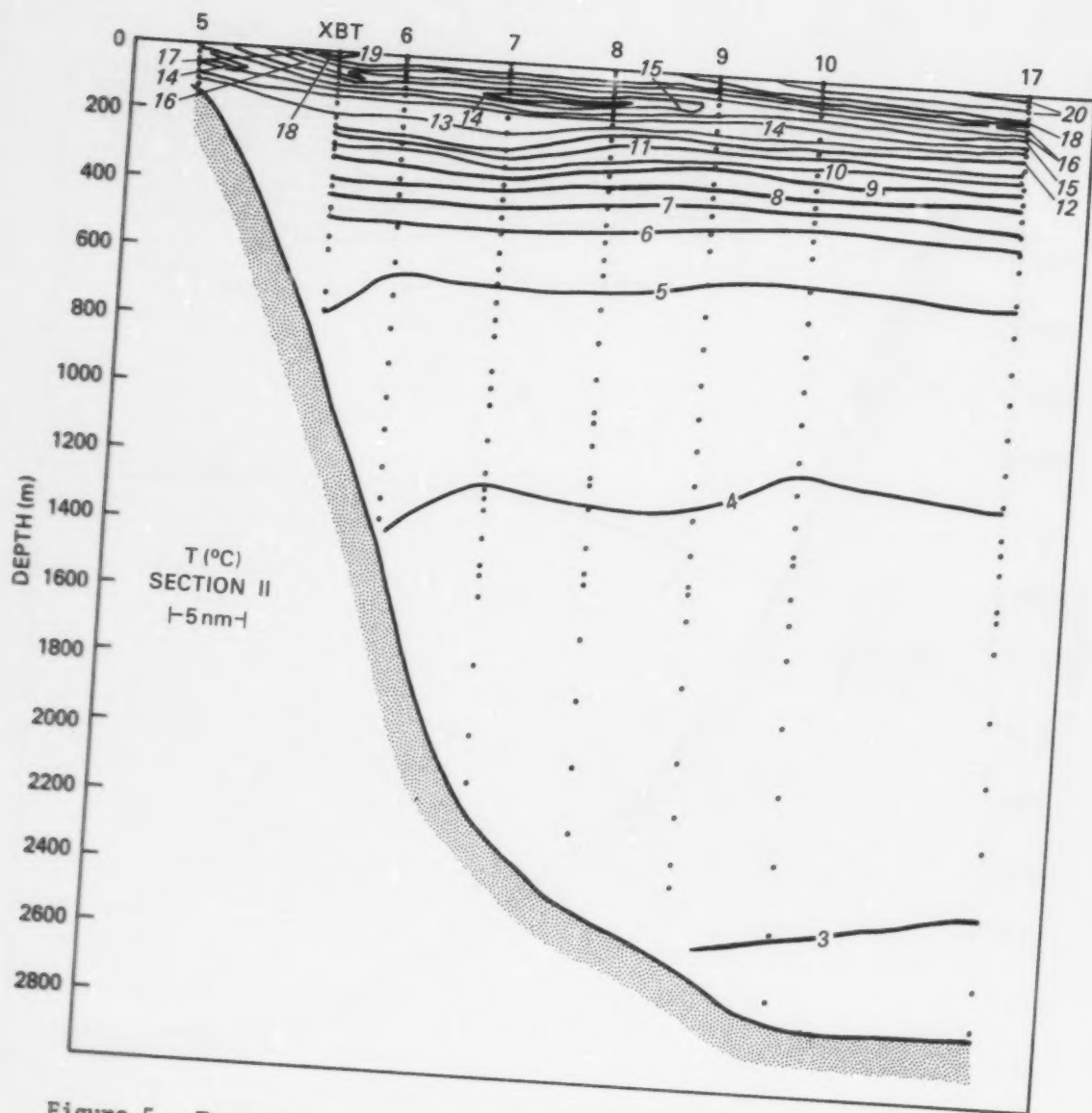


Figure 5.--Temperature, section II. Albatross IV cruise May 1974.

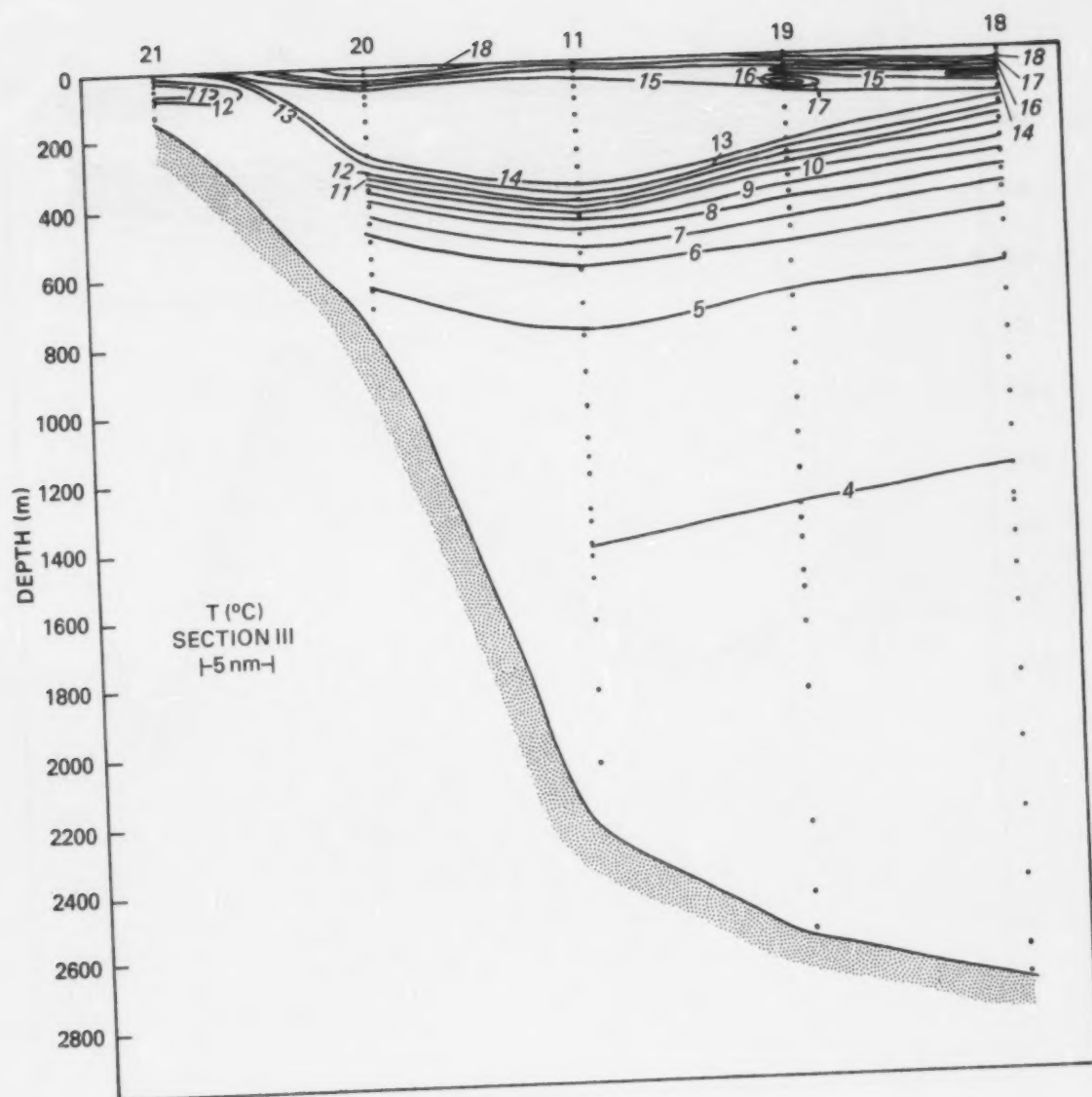


Figure 6.--Temperature, section III, Albatross IV cruise May 1974.

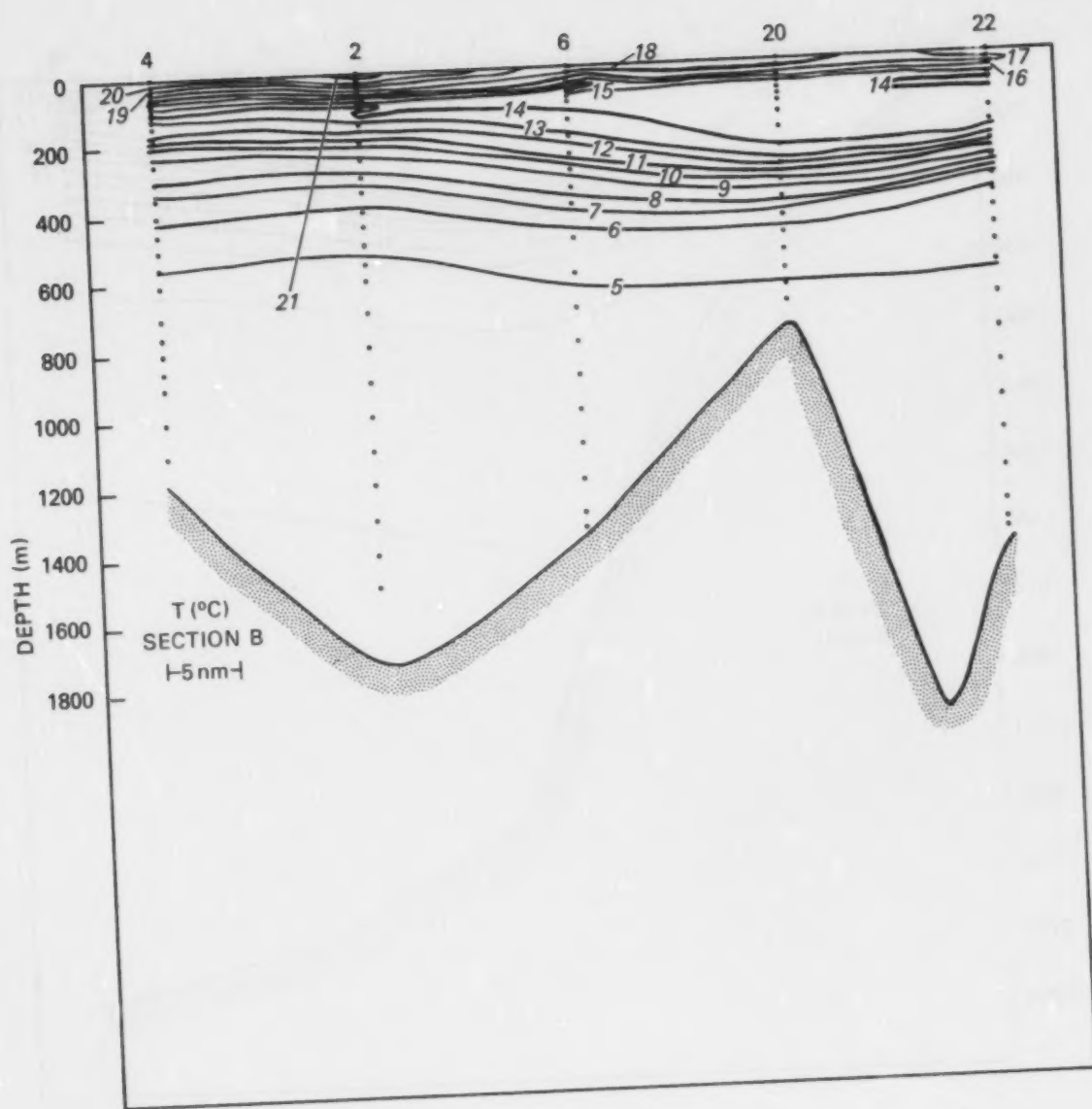


Figure 7.--Temperature, section B, Albatross IV cruise May 1974.

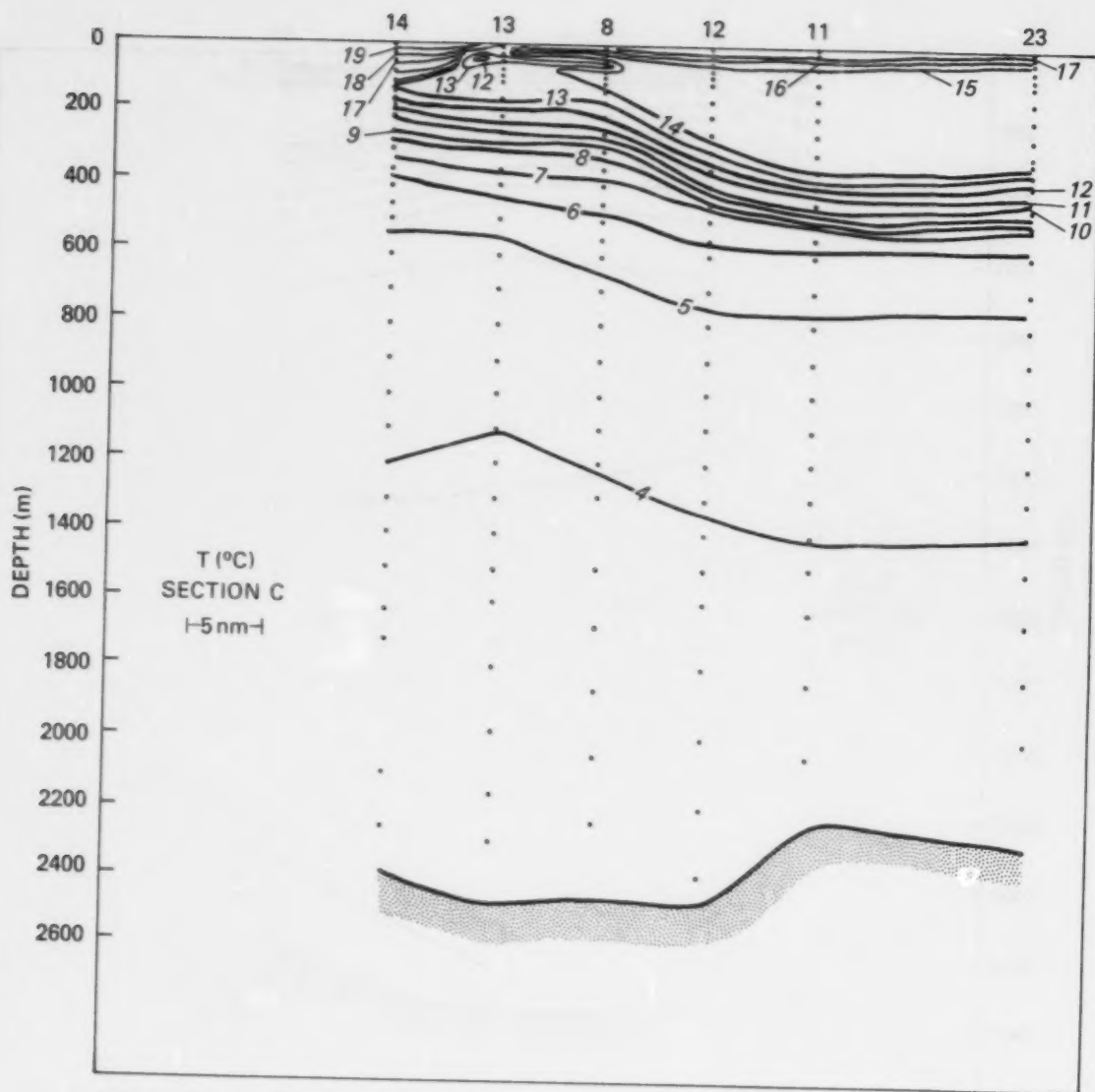


Figure 8.--Temperature, section C, Albatross IV cruise May 1974.

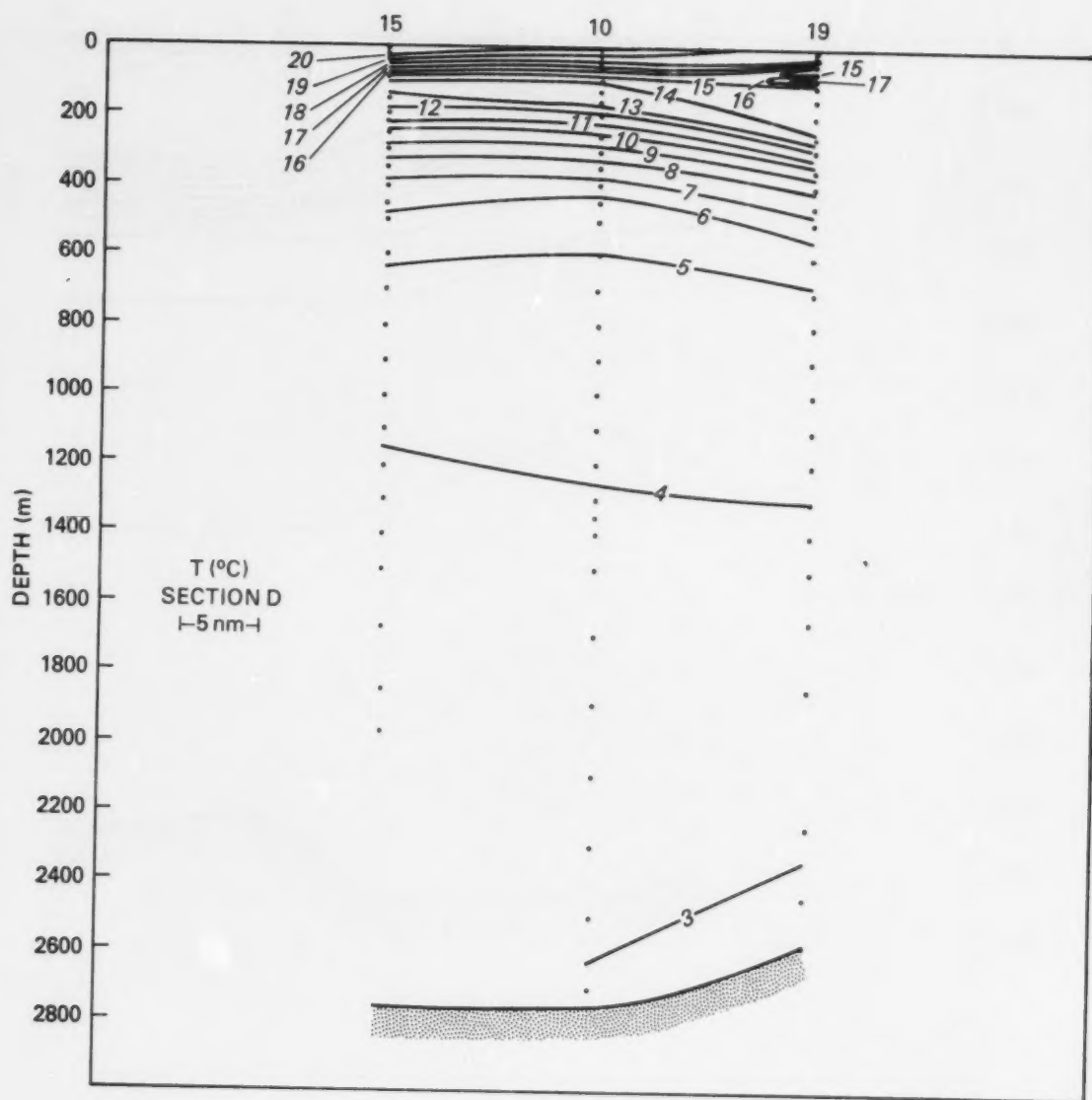


Figure 9.--Temperature, section D, Albatross IV cruise May 1974.

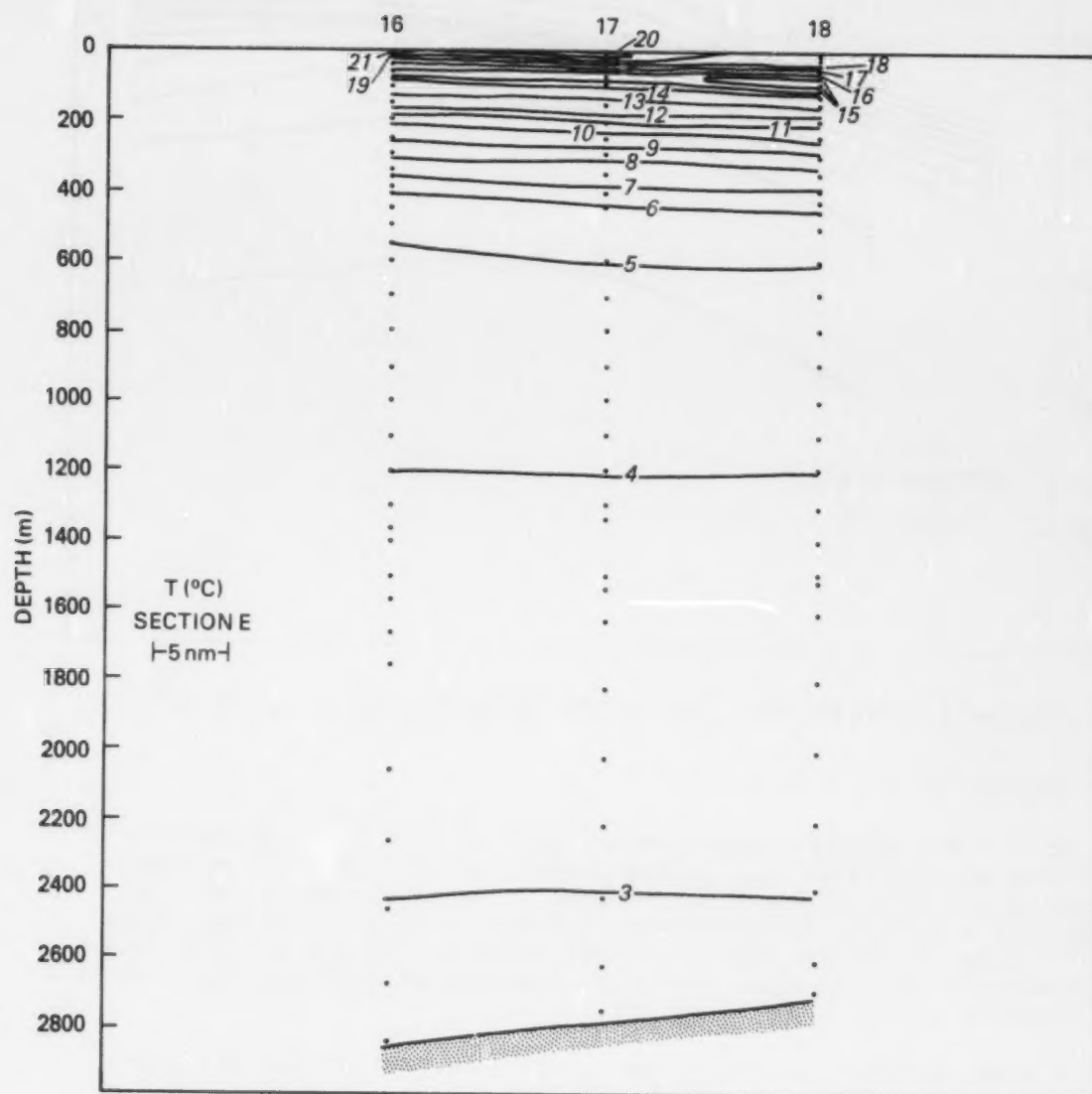


Figure 10.--Temperature, section E, Albatross IV cruise May 1974.

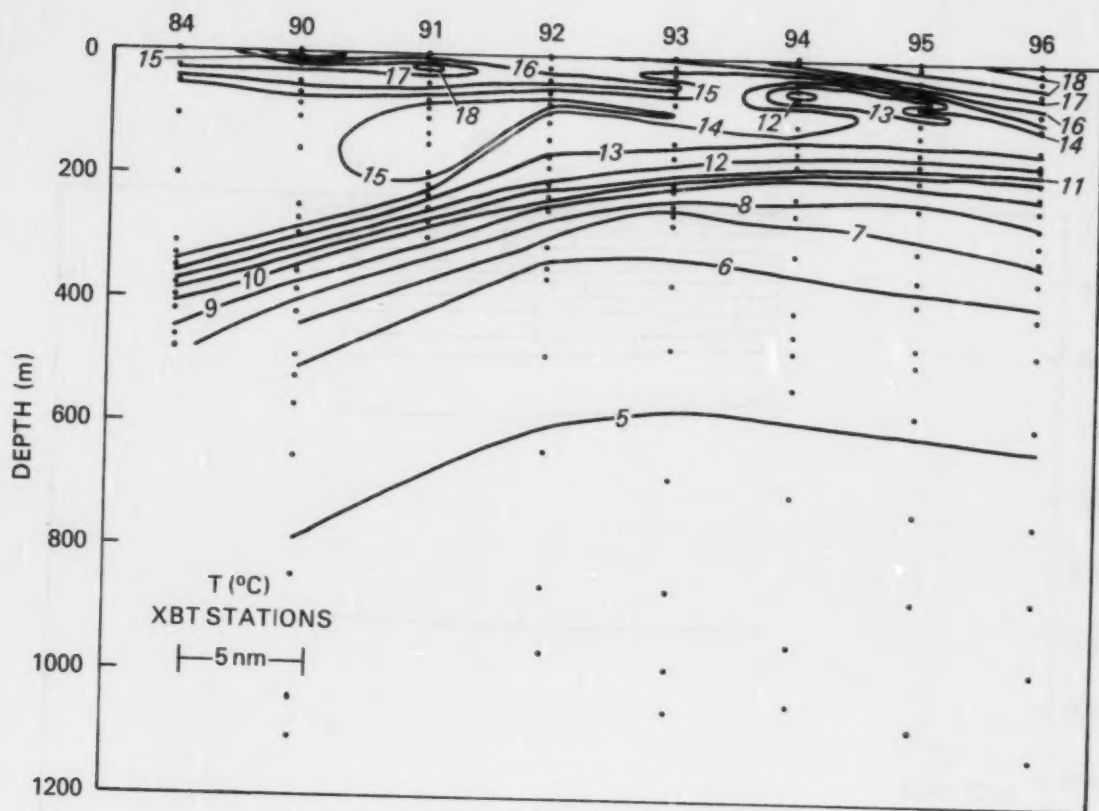


Figure 11.--Temperature, XBT section, Albatross IV cruise May 1974.

Salinity (figs. 2, 3, 12-18)

Sea surface salinity ranged between 32.9 and 36.0 o/oo and generally increased seaward (fig. 2). As for temperature, the upper 100 m showed layers of intruding high and low salinity. From approximately 200 m to about 1600 m salinity decreased from 35.5 o/oo to about 34.94 o/oo. From 1600 m to the bottom salinity inversions occurred with some salinity values increasing to above 35 o/oo. Salinity inversions at depth have been reported by Fuglister (1960) (figs. 3, 12-18).

A layer of higher salinities was found in conjunction with the higher temperatures at stations 11, 12, 19, 20, and 23. The salinity ranged between 35.59 and 35.96 o/oo from the surface to 350 m (figs. 14, 11). The salinity in the upper 50 m at these stations was approximately 35.8 o/oo, but along with the lower temperatures was found to be characteristic of slope water. The highest salinity values were found to occur between 200 and 300 m.

Generally in the upper 100 m the areas of low salinity corresponded to areas of low temperature and low oxygen. Some areas of high salinity also corresponded to areas of low oxygen.

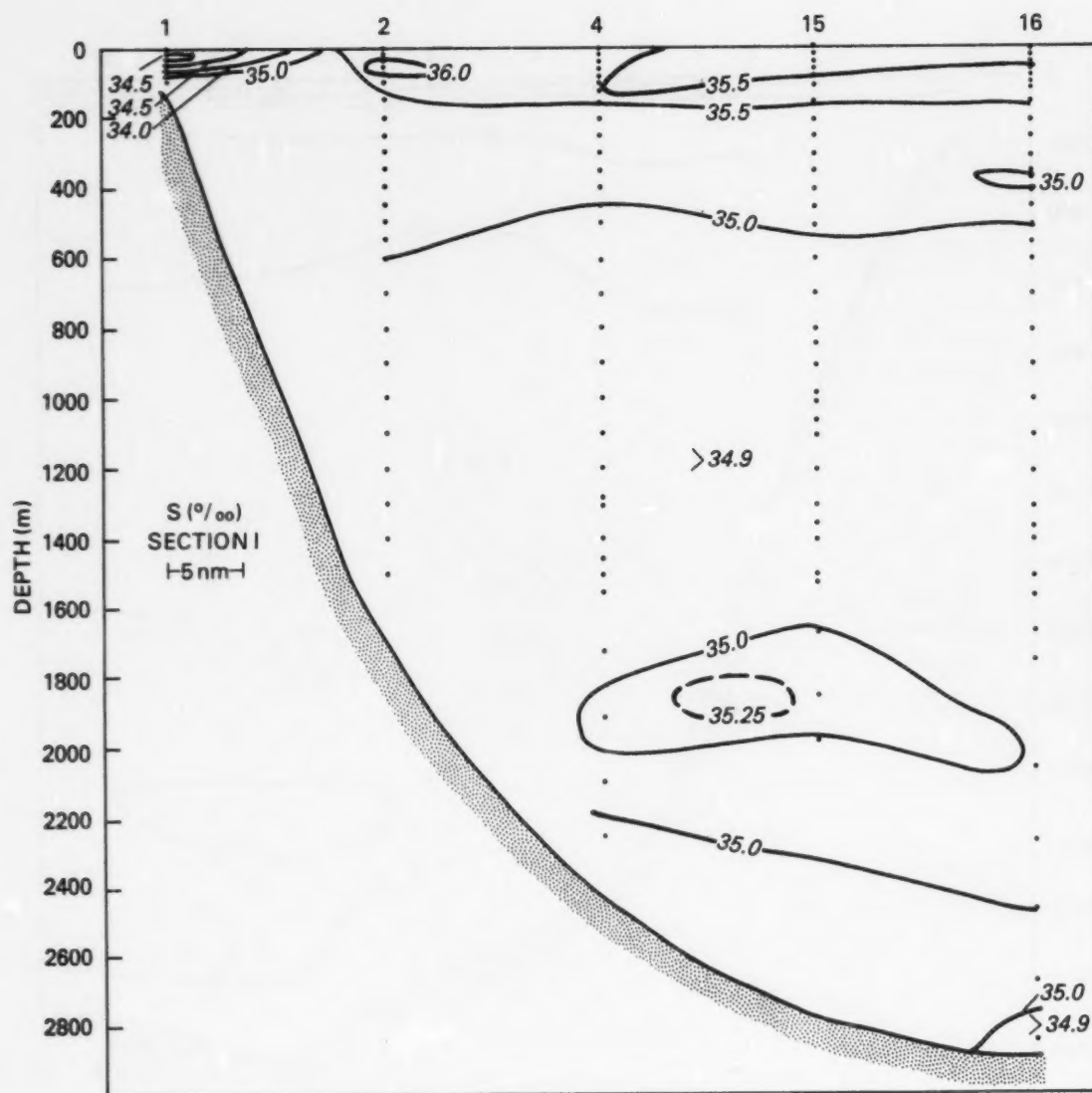


Figure 12.--Salinity, section I, Albatross IV cruise May 1974.

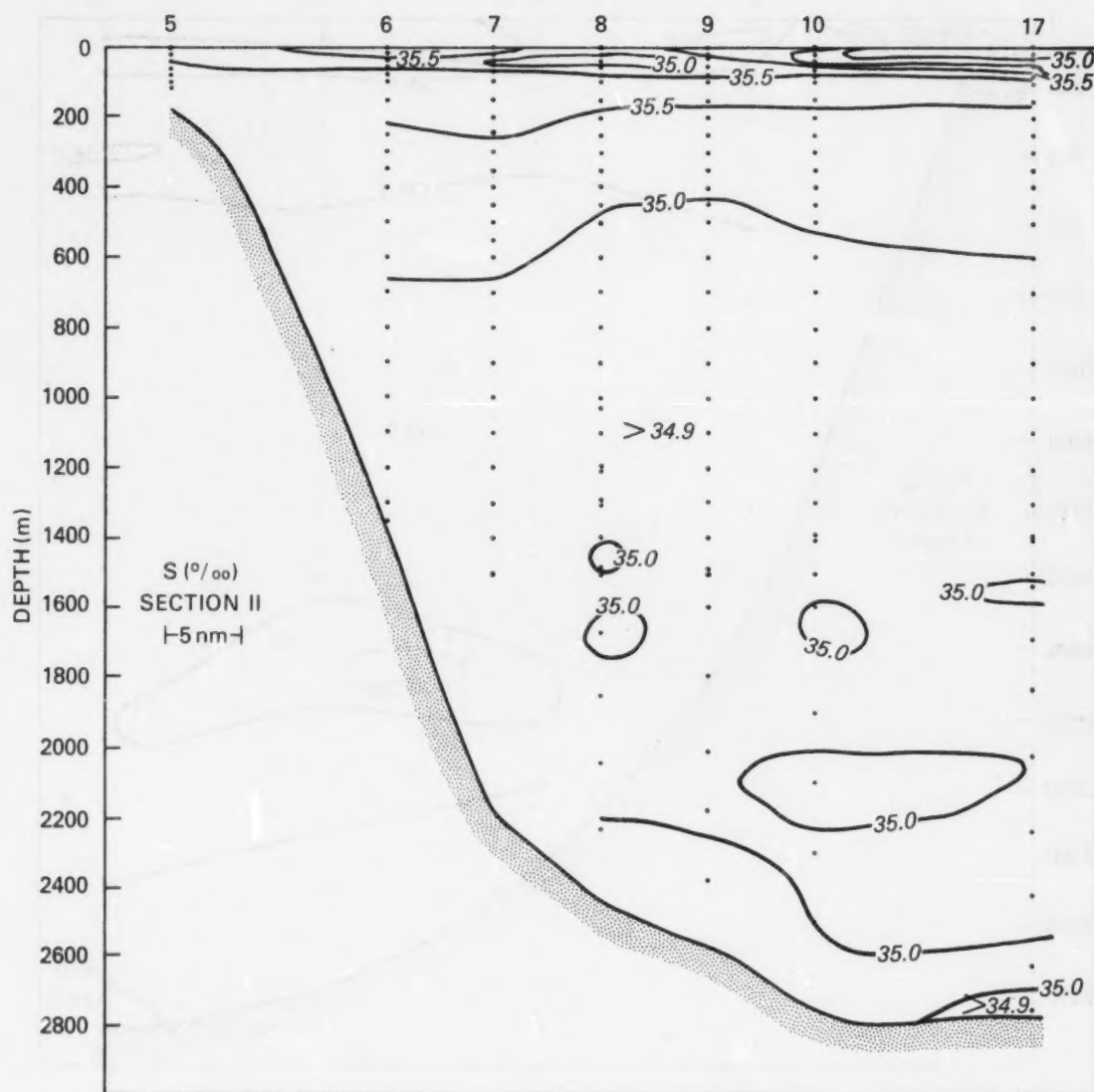


Figure 13.--Salinity, section II, Albatross IV cruise May 1974.

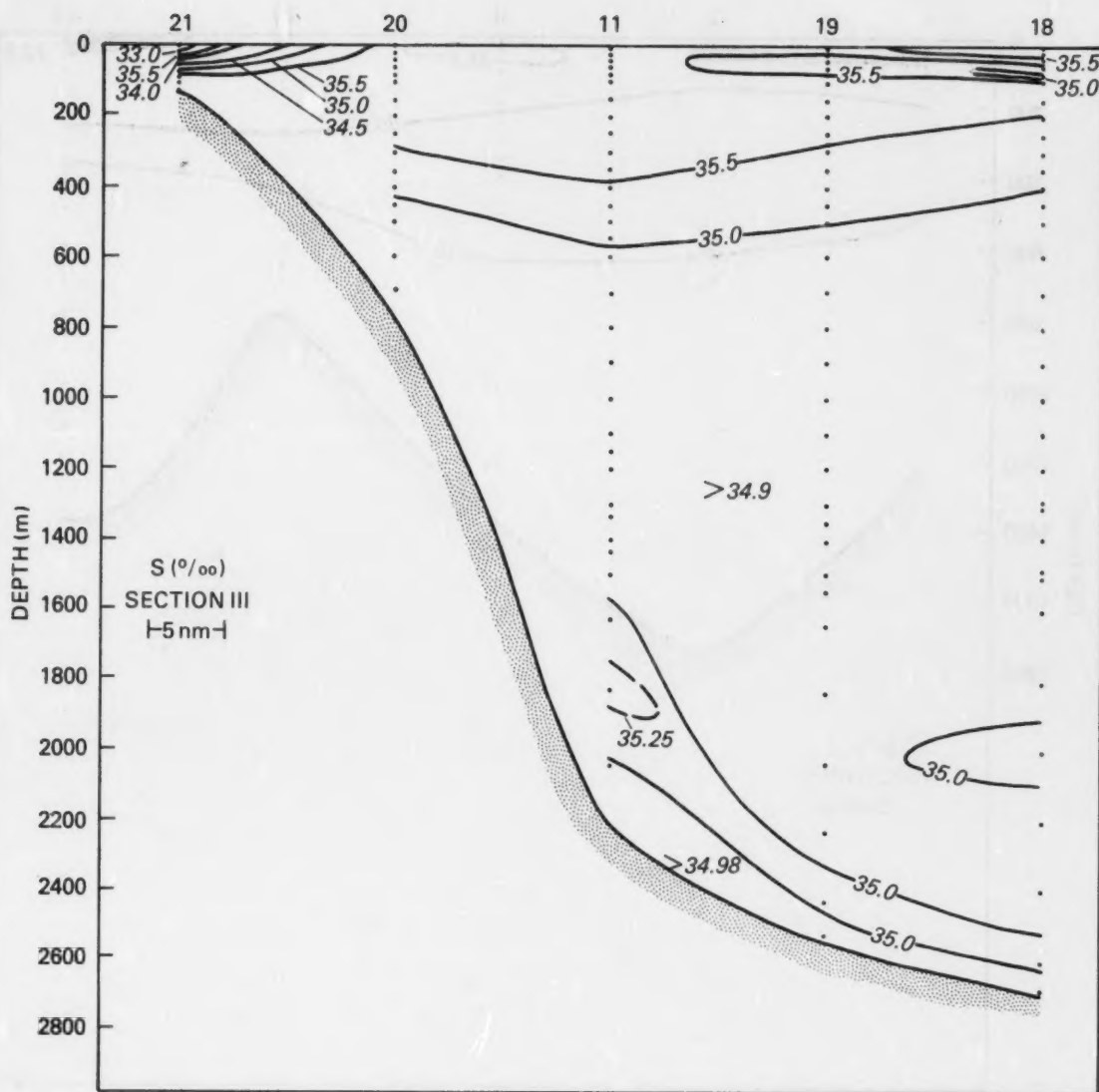


Figure 14.--Salinity, section III, Albatross IV cruise May 1974.

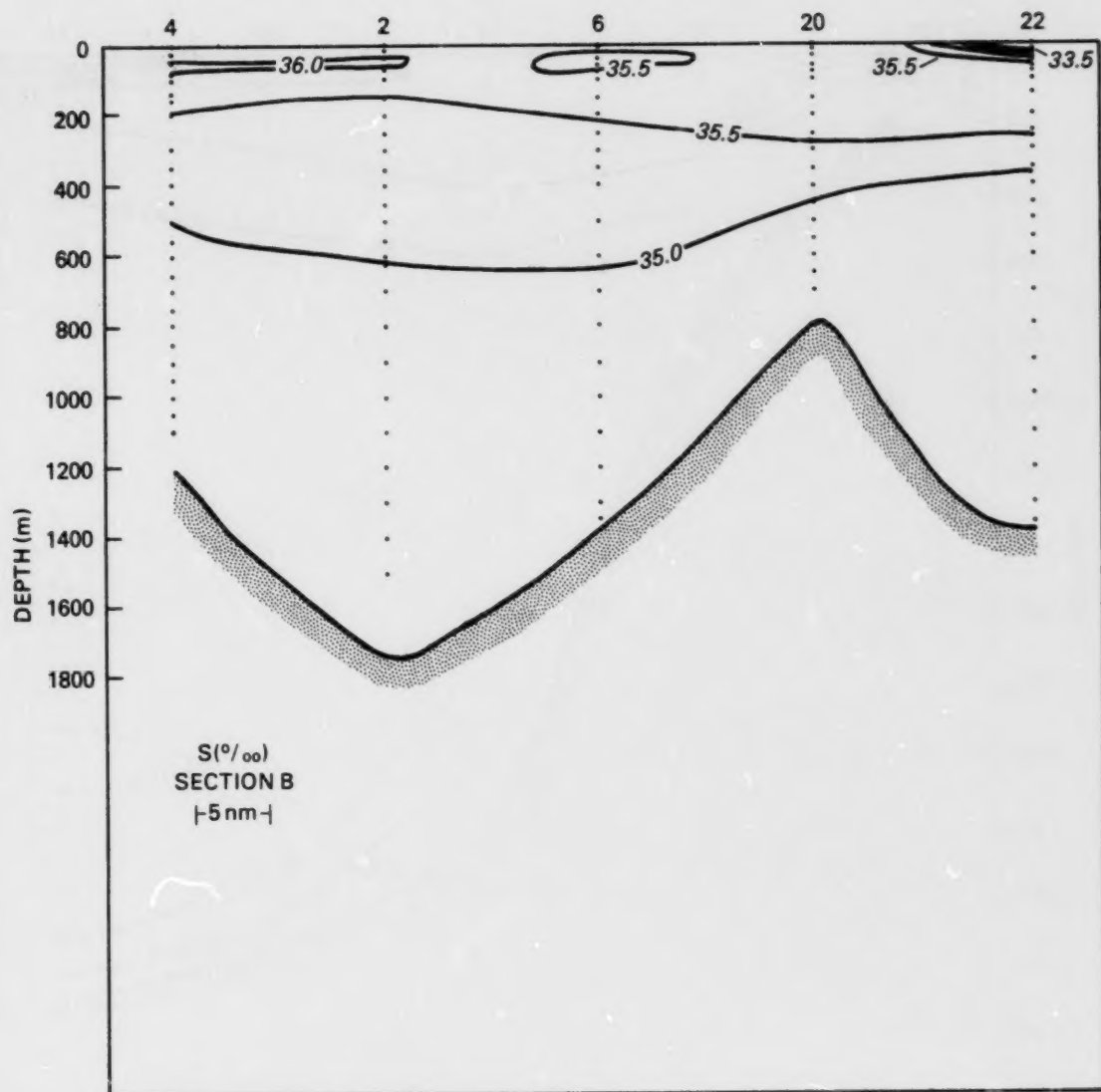


Figure 15.--Salinity, section B, Albatross IV cruise May 1974.

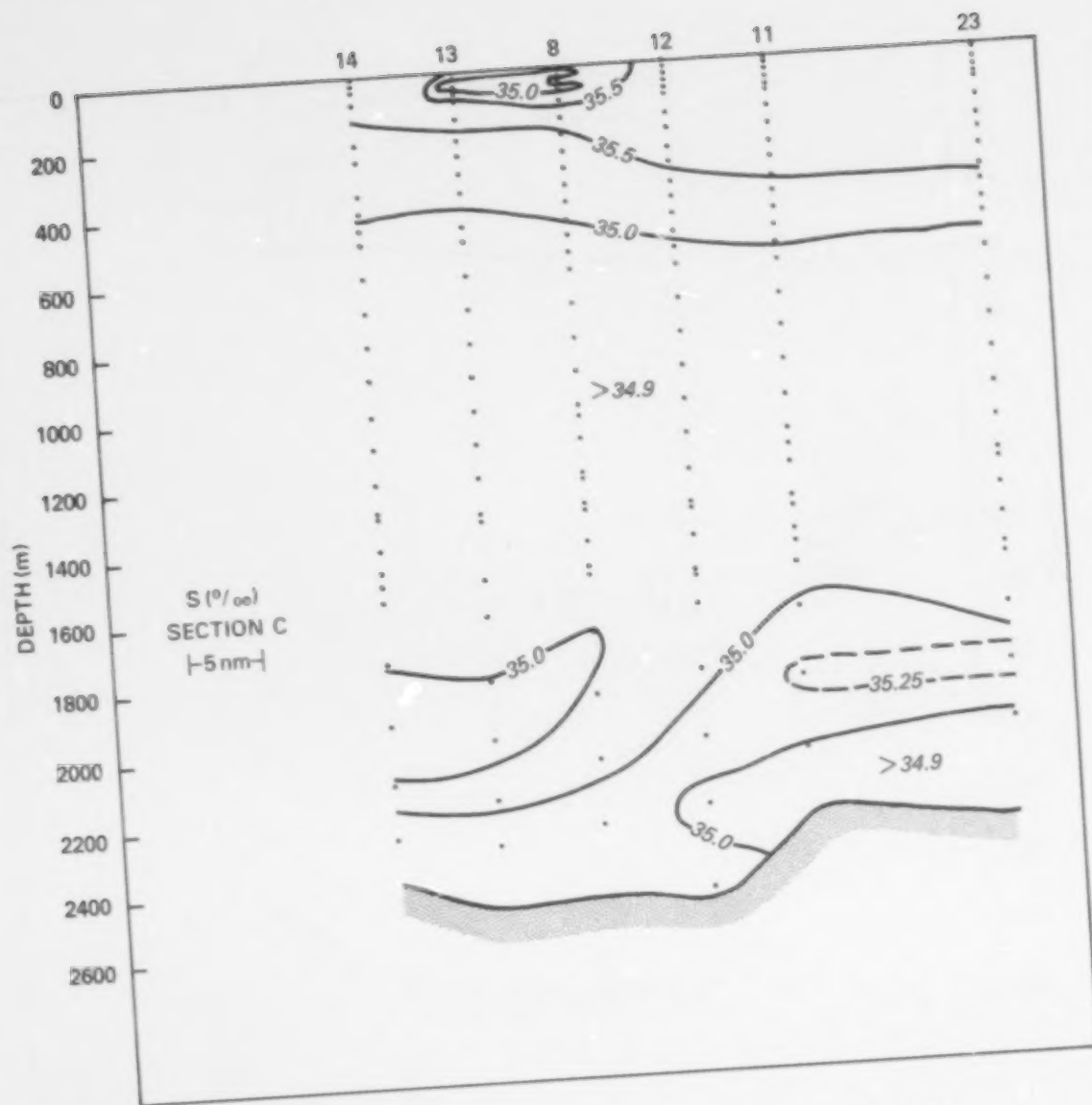


Figure 16.--Salinity, section C, Albatross IV cruise May 1974.

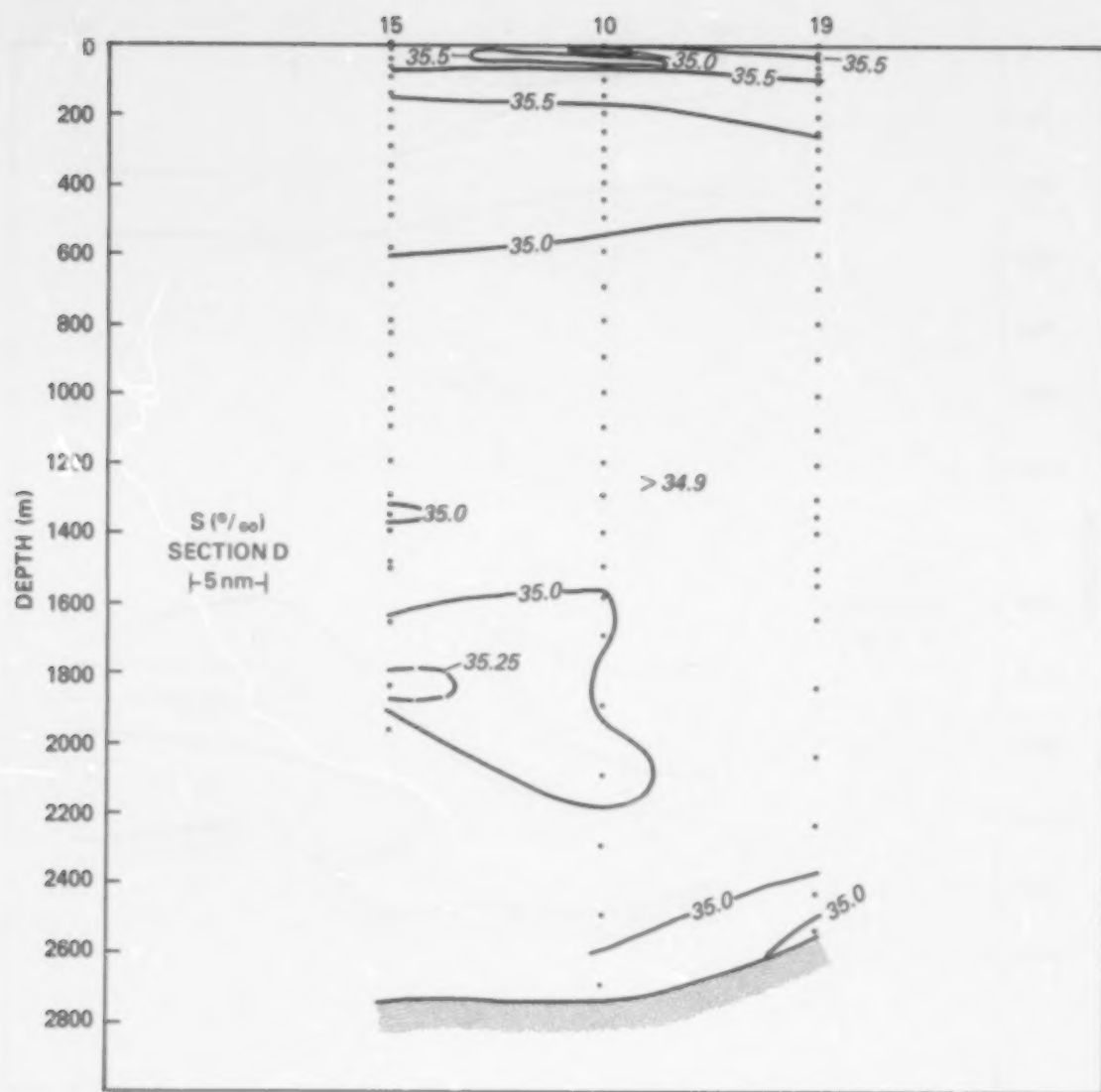


Figure 17.--Salinity, section D, Albatross IV cruise May 1974.

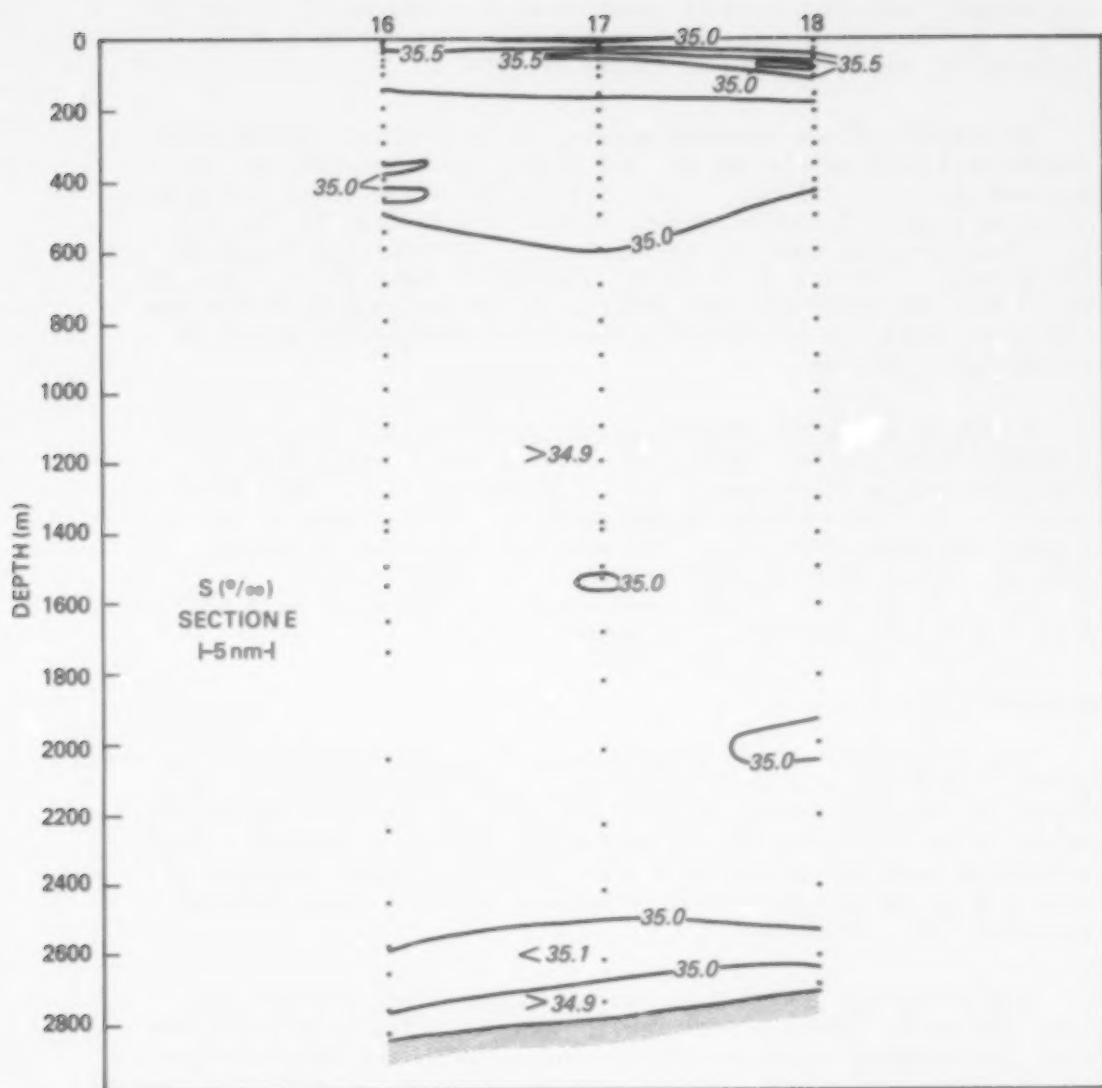


Figure 18.--Salinity, section E, Albatross IV cruise May 1974.

Oxygen (figs. 2, 3, 19-25)

The amount of dissolved oxygen at the surface ranged from 6.94 to 4.36 ml/L (fig. 2). The highest values occurred over the continental shelf and generally decreased seaward. In the upper 100 m pockets of low oxygen (less than 4 ml/L) occurred at stations 4, 2, 8, and 19 (figs. 21, 22, 23). Pools of high oxygen (greater than 6 ml/L) occurred at stations 1 and 11 (figs. 19, 21).

An oxygen minimum occurred between 200 and 400 m. Values were lowest at approximately 300 m. The lowest value recorded for the minimum layer was 3.12 ml/L. Most of the values recorded for this layer were about 3.2 ml/L (figs. 19-25). At stations 11, 12, 20, and 23 in the warm eddy the average amount of dissolved oxygen in the minimum layer was 4.13 ml/L at a depth of about 500 m (figs. 21, 23). Also, at these stations and station 19 the oxygen content was higher at depths of 100 to 350 m than for corresponding depths at neighboring stations.

At depths below the oxygen minimum layer, values increased to slightly above 6 ml/L. From 1200 m to the bottom the amount of dissolved oxygen fluctuated between 6.2 and 5.3 ml/L. The lowest values of dissolved oxygen in bottom waters corresponded to the highest recorded salinities. The most extreme value of oxygen in this deep water (4.43 ml/L) occurred at the most extreme value of salinity (35.29 o/oo). Low oxygen values in deep water near this region have been recorded in Muromtsev (1963).

Sigma-t (figs. 2, 26-32)

Density was determined using methods based on Bjerknes and Sandstrom (1910). From the density determinations, dynamic depths were calculated for the observed depths and then were interpolated for standard depths using a three-point Lagrangian interpolation (Rattray, 1962). Velocities were determined from this. The geostrophic calculations were made by using the methods of Bennett (1959). These data are available from the author.

Sigma-t values generally increased seaward from 24.5 to 26.0 (fig. 2) and to about 26.5 at 100 m. Instabilities occurred in the upper 100 m where temperature or salinity inversions resulted from shelf water overriding or mixing with slope water. The 27.00 isopycnal varied in depth from 200 to 400 m. The deepest depth of the 27.00 isopycnal was at stations where the warm eddy was located (figs. 28, 30). The sigma-t value in the eddy, between depths of 50 and 350 m, was near 26.8. At depths below the 27.00 isopycnal, sigma-t values increased to 27.9 near the bottom.

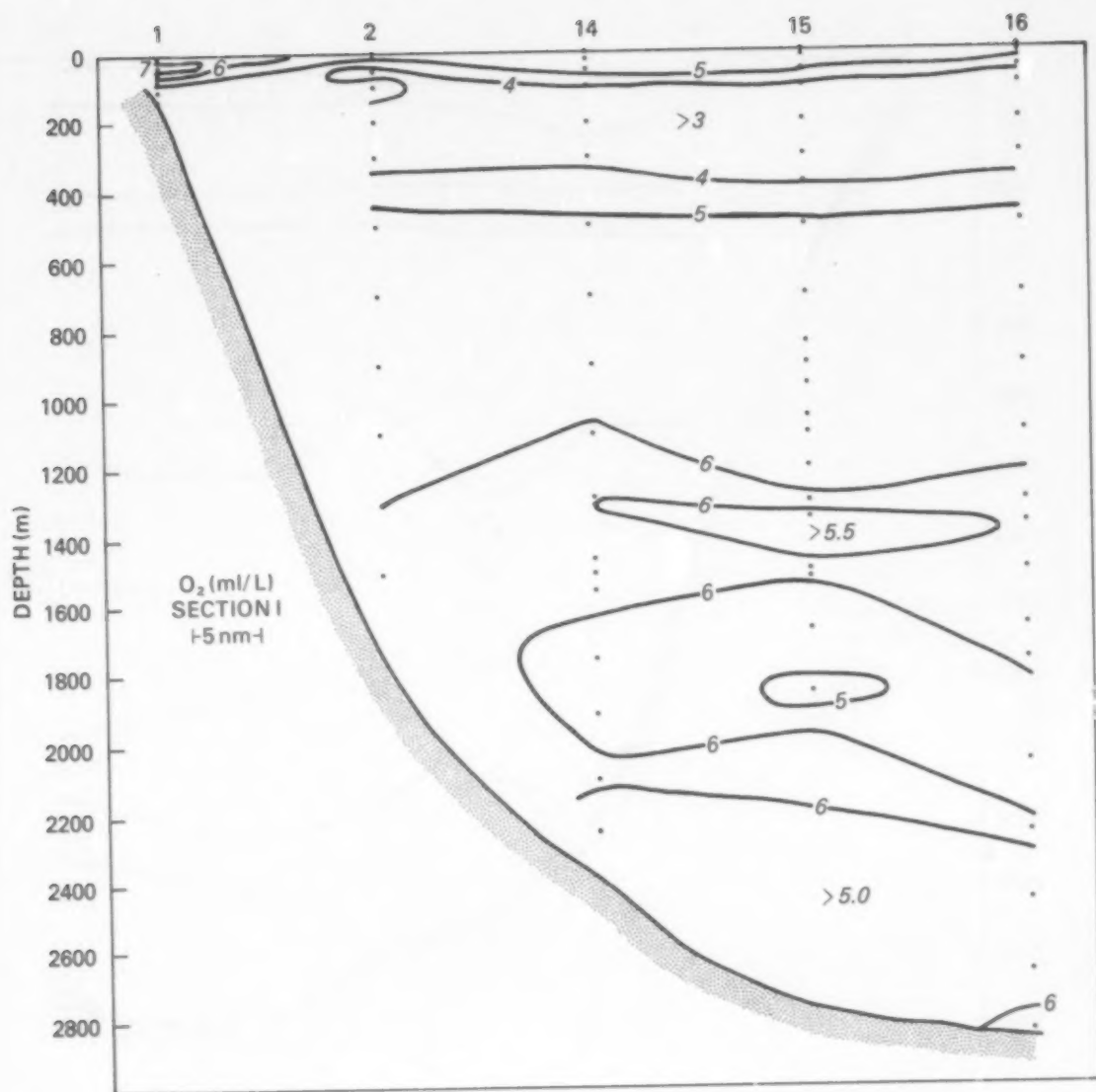


Figure 19.--Oxygen, section I, Albatross IV cruise May 1974.

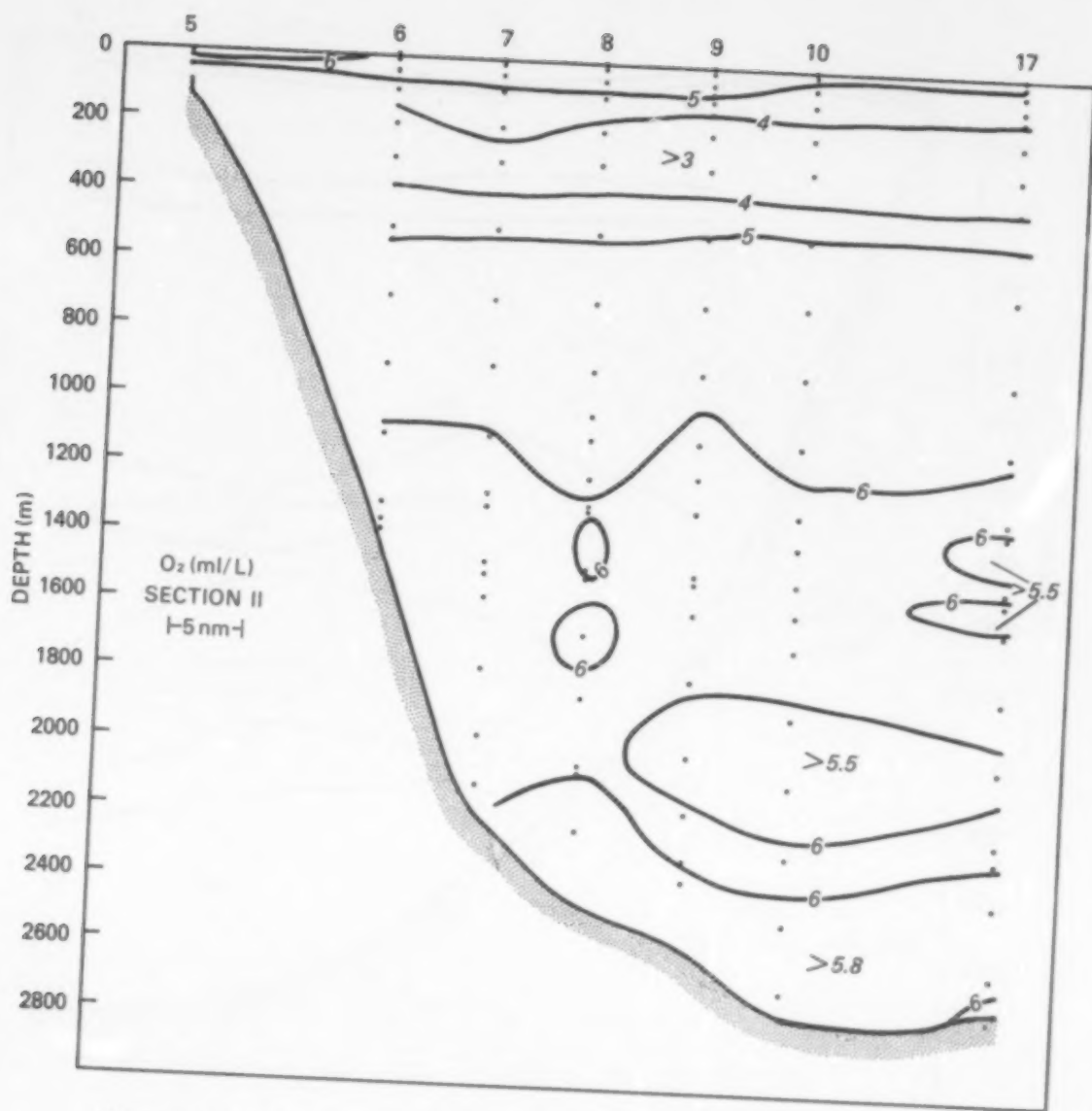


Figure 20.--Oxygen, section II, Albatross IV cruise May 1974.

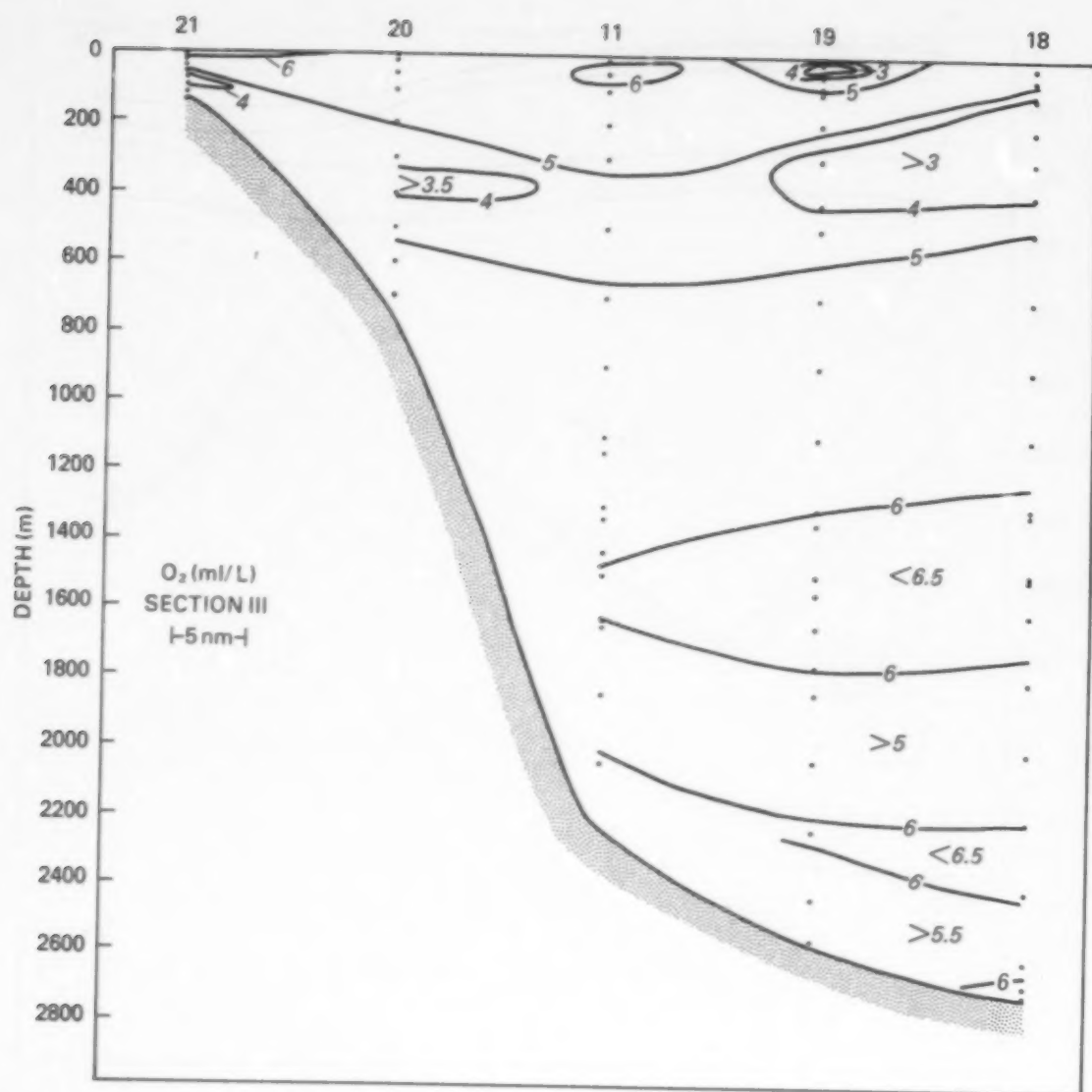


Figure 21.--Oxygen, section III, Albatross IV cruise May 1974.

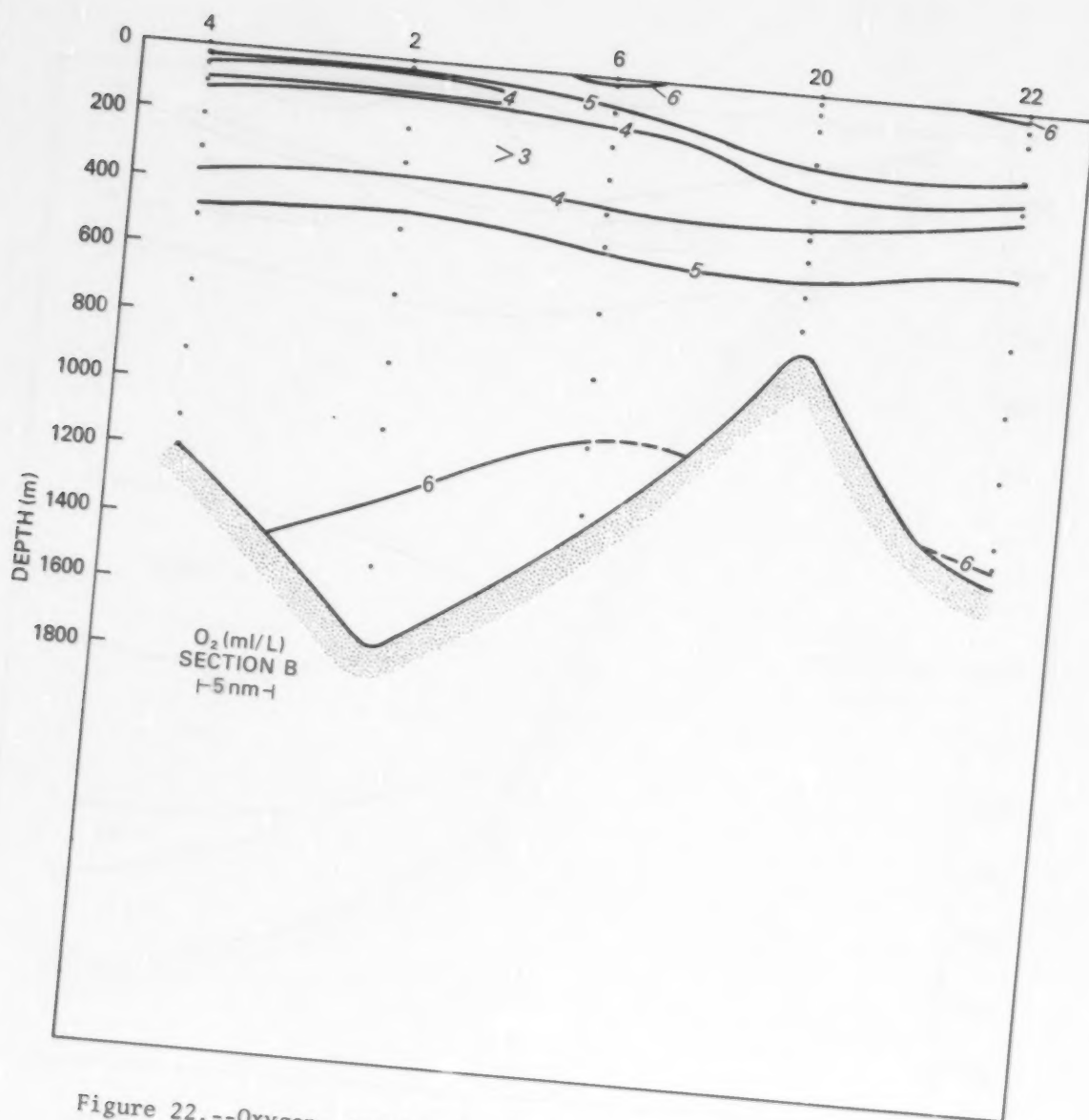


Figure 22.--Oxygen, section B, Albatross IV cruise May 1974.

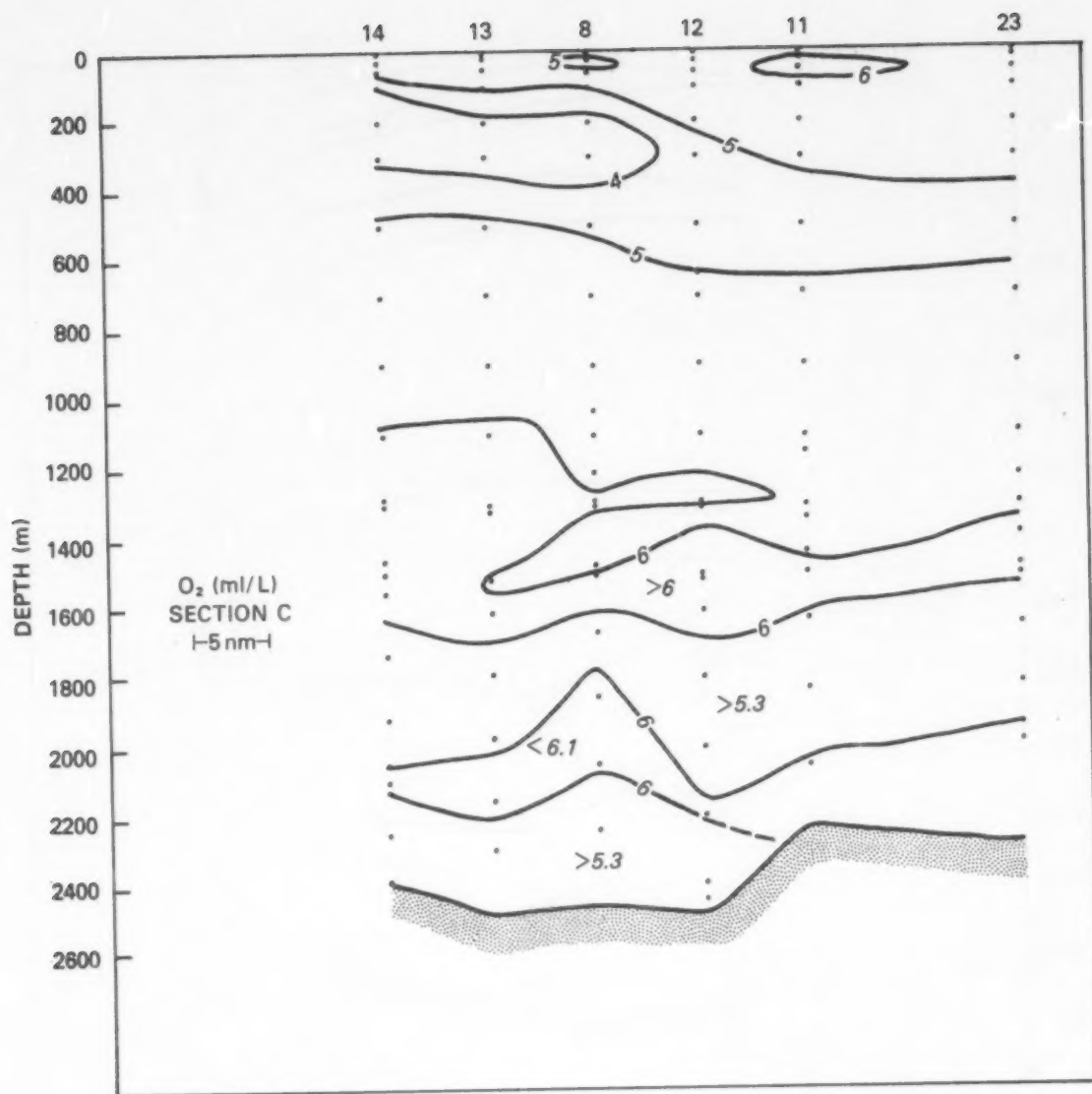


Figure 23.--Oxygen, section C, Albatross IV cruise May 1974.

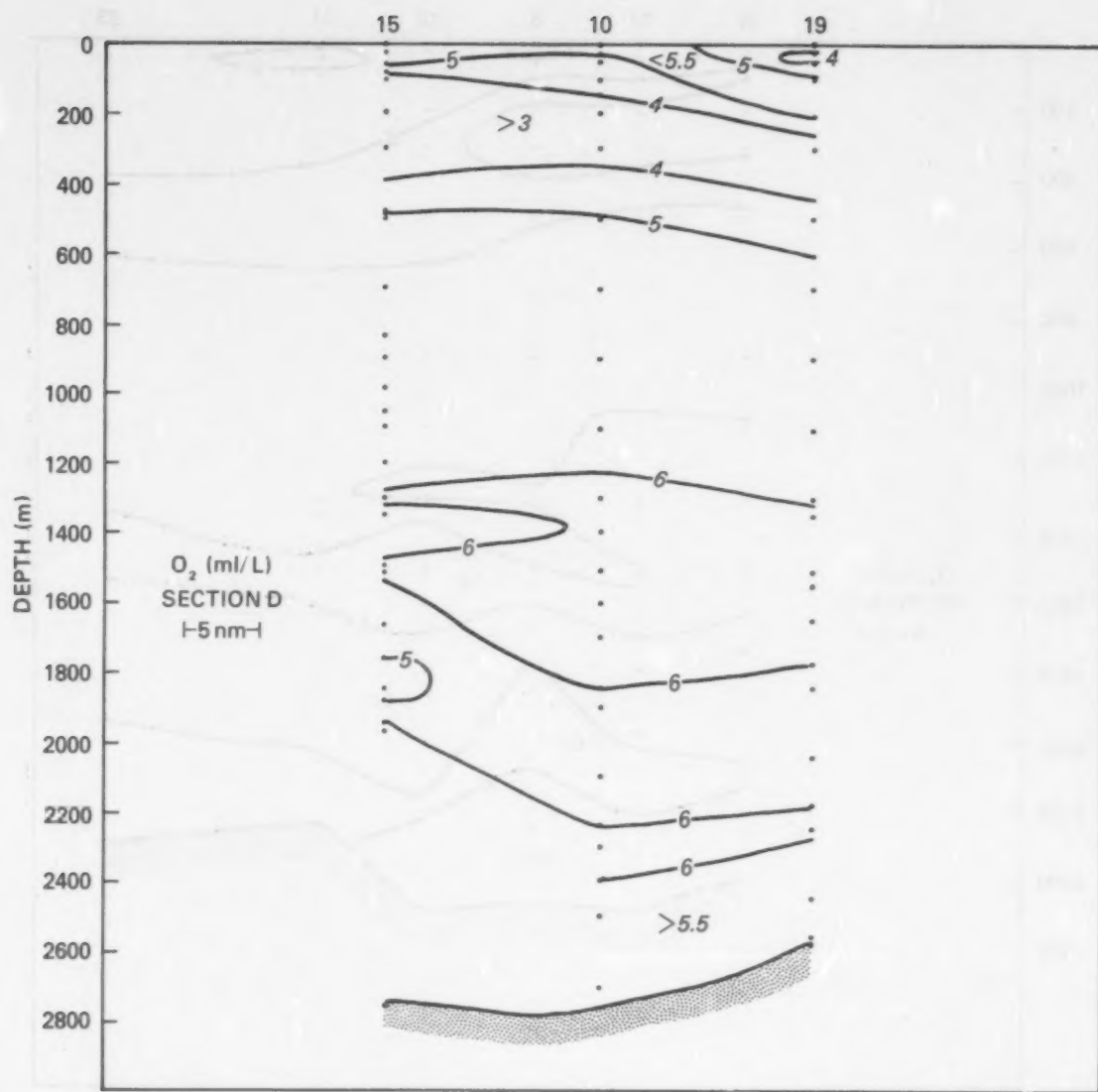


Figure 24.--Oxygen, section D, Albatross IV cruise May 1974.

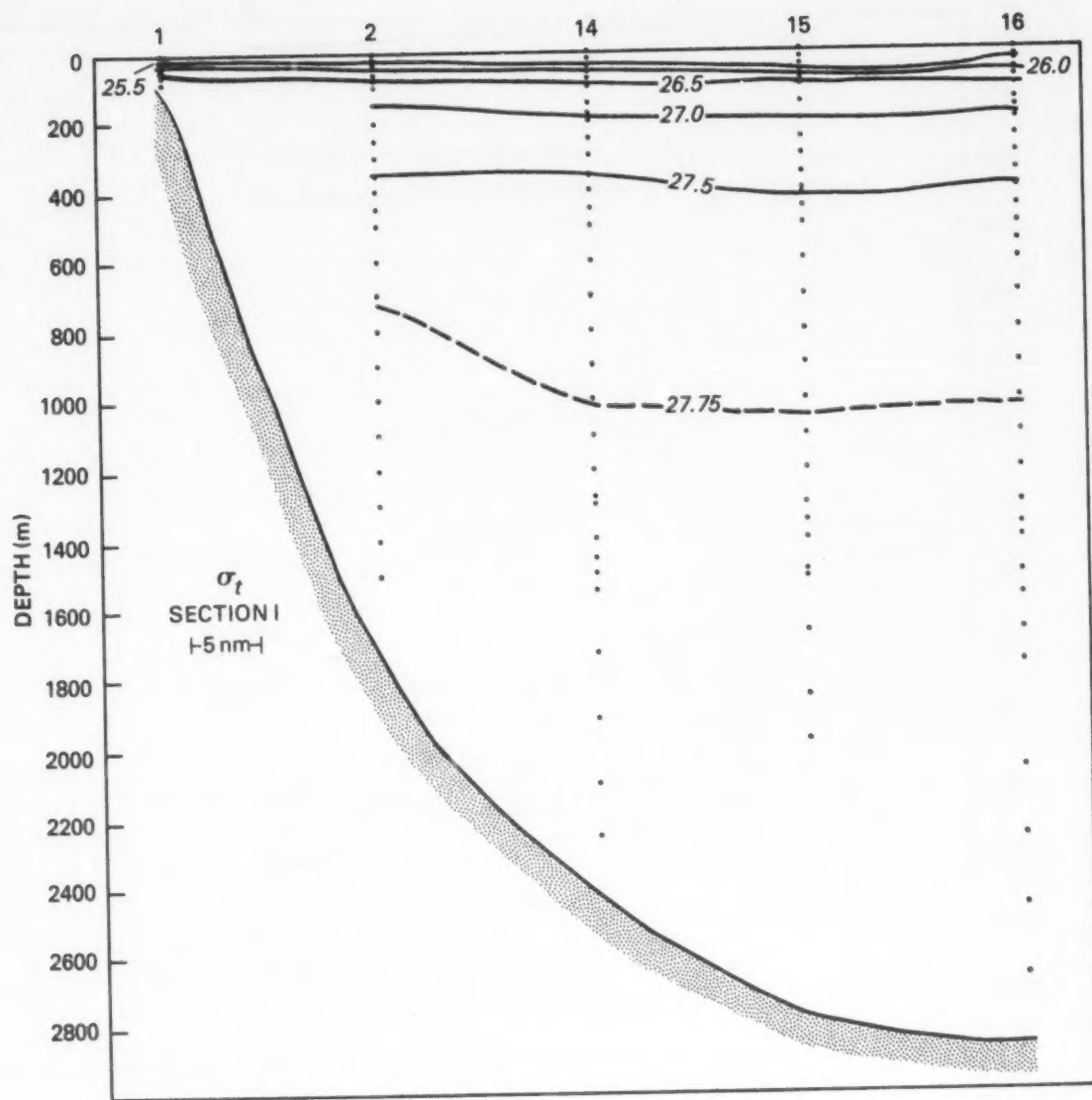


Figure 26.--Sigma-t, section I, Albatross IV cruise May 1974.

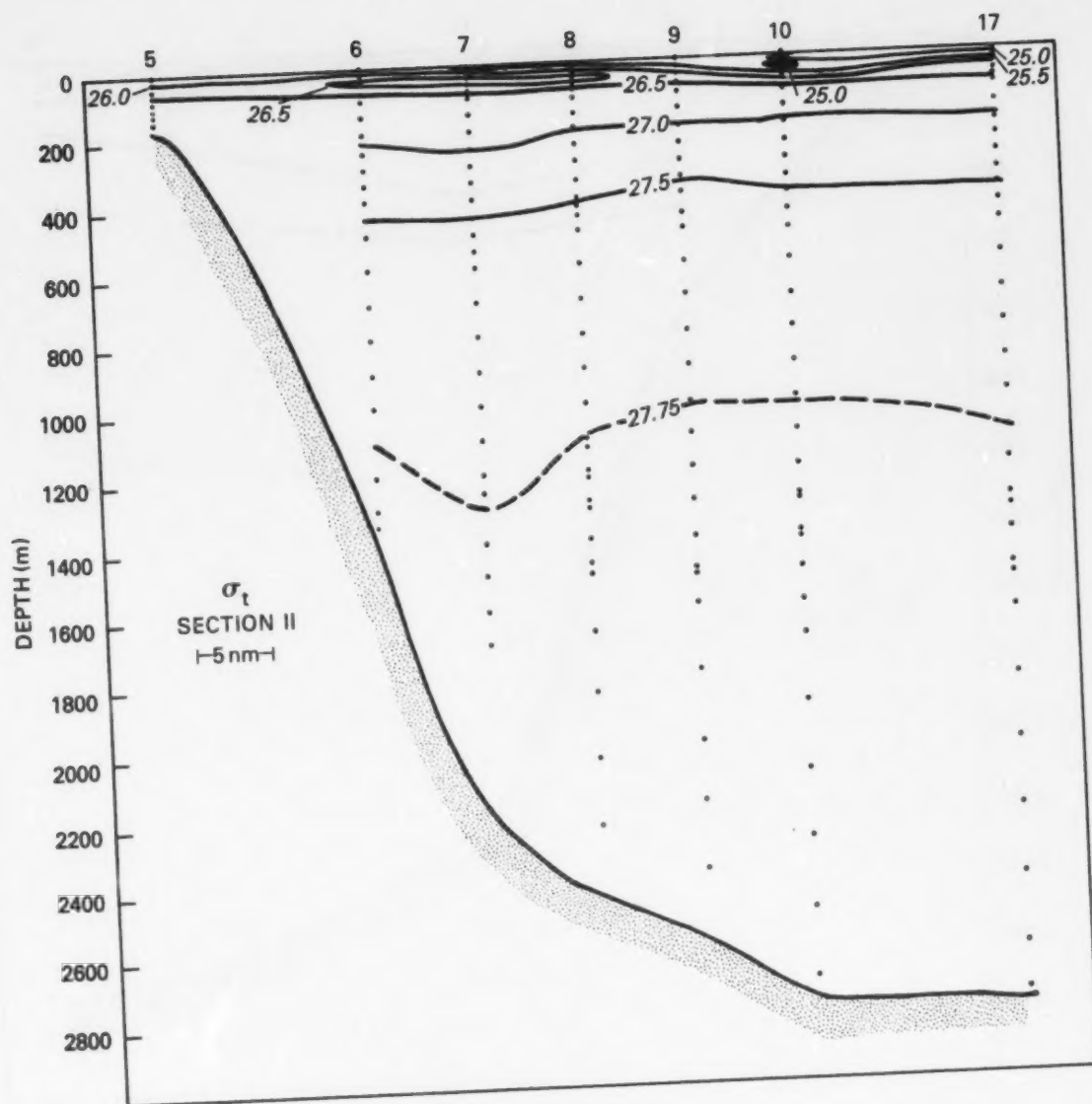


Figure 27.--Sigma-t, section II, Albatross IV cruise May 1974.

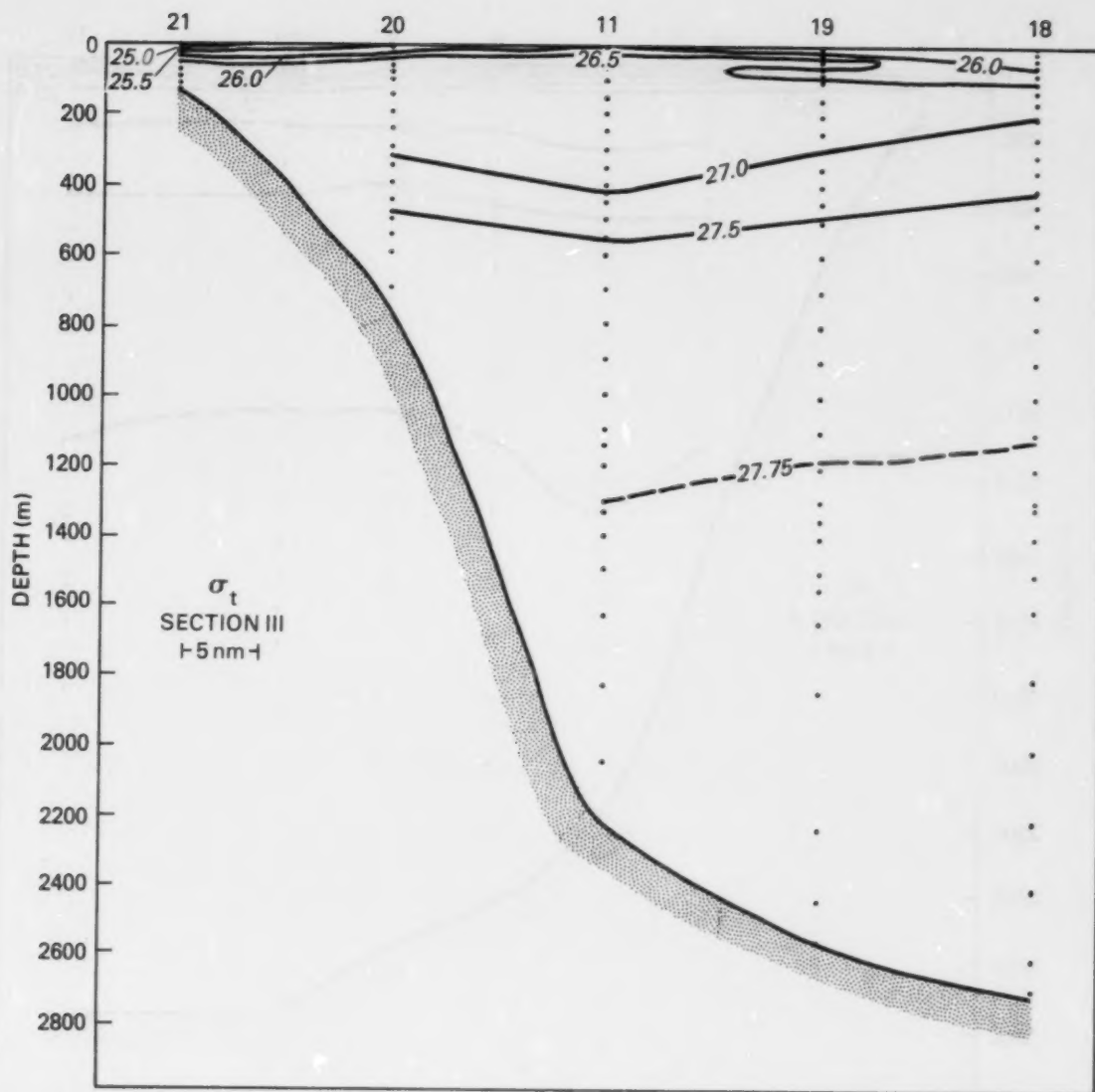


Figure 28.--Sigma-t, section III, Albatross IV cruise May 1974.

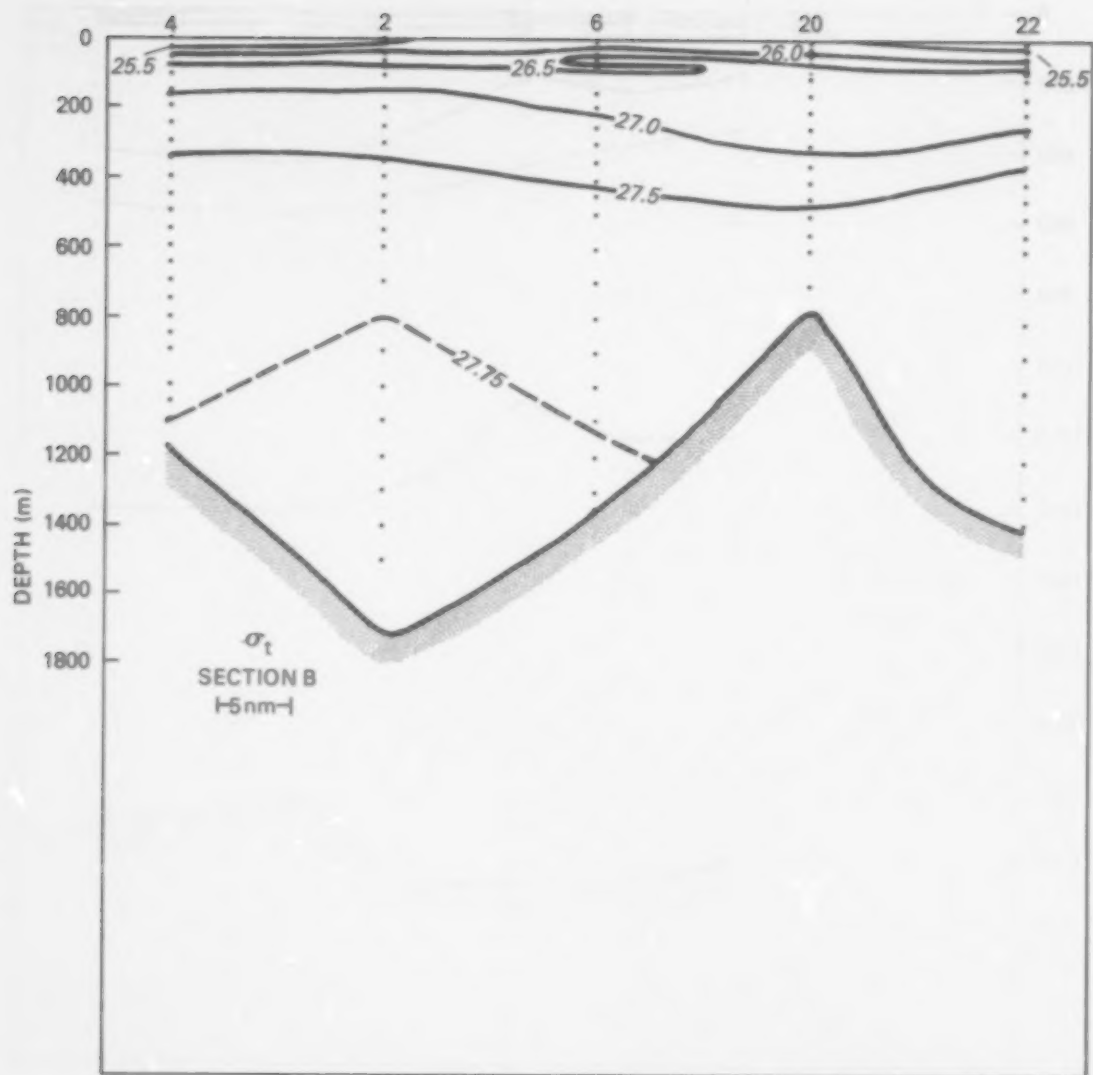


Figure 29.--Sigma-t, section B, Albatross IV cruise May 1974.

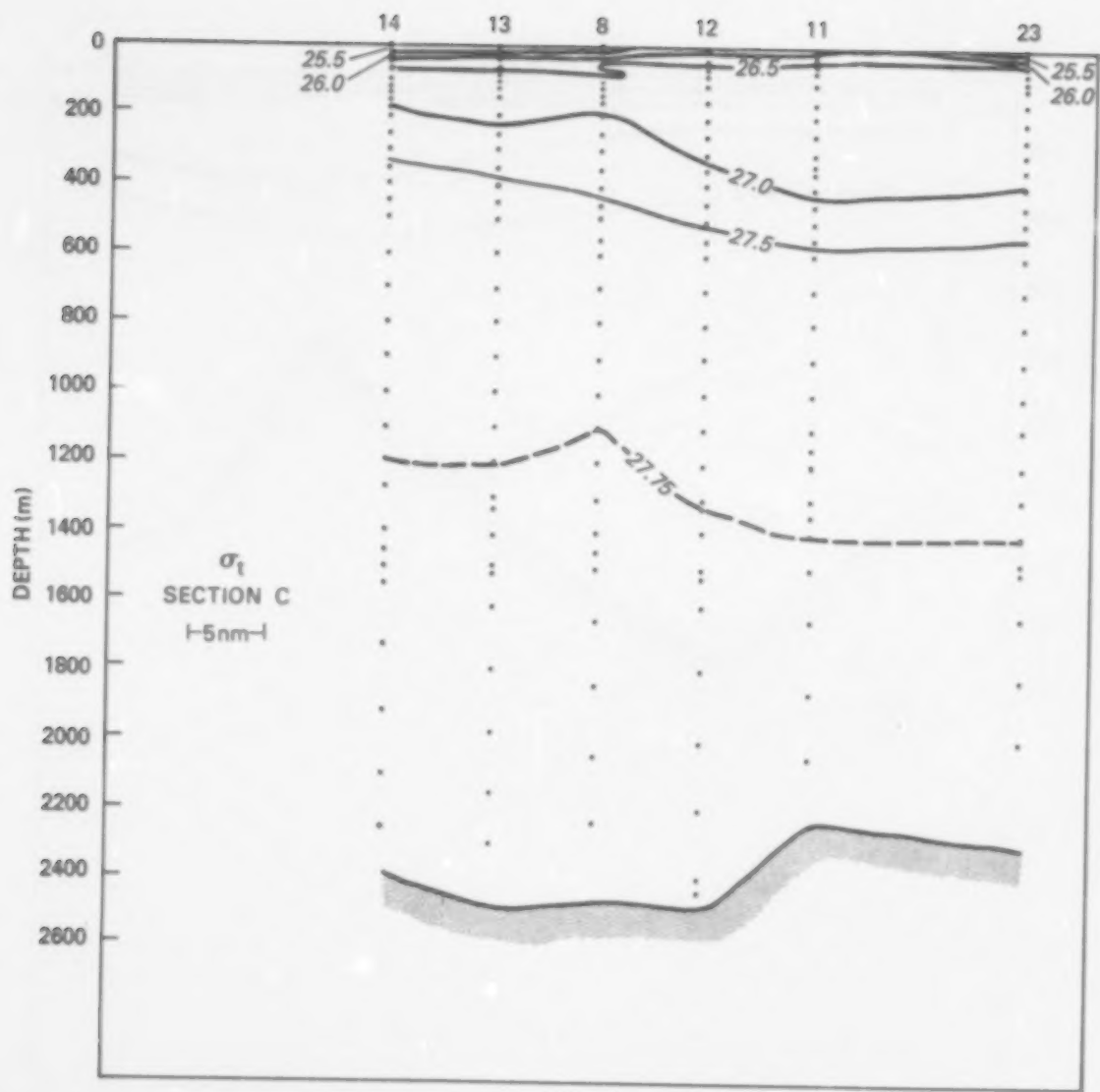


Figure 30.--Sigma-t, section C, Albatross IV cruise May 1974.

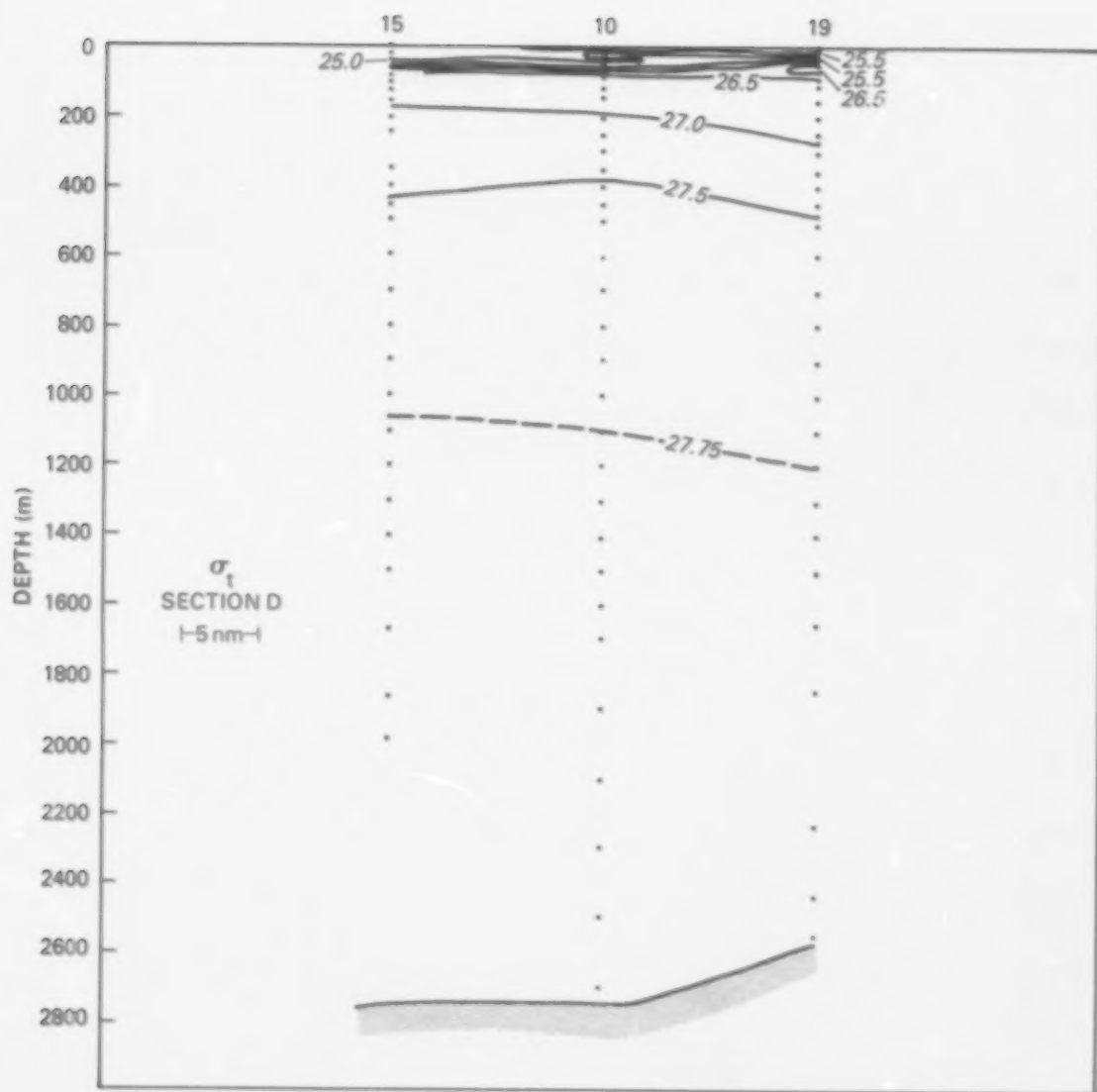


Figure 31.--Sigma-t, section D, Albatross IV cruise May 1974.

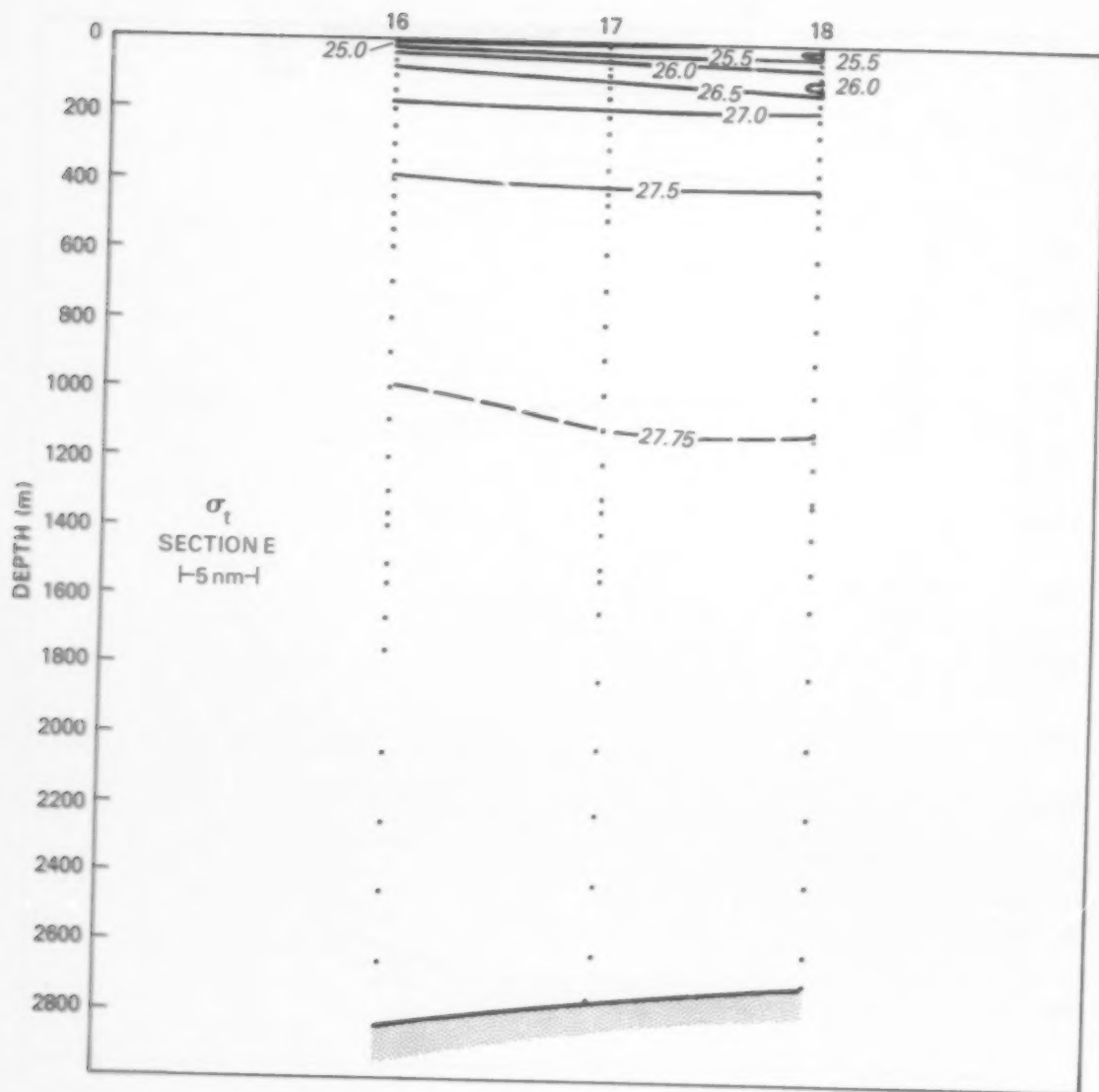


Figure 32.--Sigma-t, section E, Albatross IV cruise May 1974.

WATER MASSES

That part of the temperature-salinity curve characteristic of North Atlantic Central Water (NACW) occurs between temperatures of 8° and 19°C and salinities of 35.10 and 36.70 o/oo (Sverdrup, 1942, p. 668). Between 100 and 350 m, the temperature range of station data was between 8° and 16°C--within the range for NACW. The salinity, however, was found to be slightly fresher than that of NACW, ranging between 35.0 and 35.96 o/oo. This observation is in agreement with that of Iselin (1936). In figure 33 the boundaries of NACW are shown by the solid lines and the boundaries of the station data are shown within the dotted lines. A few of the observations from the station data were found to fall inside the boundaries of the NACW. Closer observation revealed that these points correspond with the warm eddy layer discussed above. Below 350 m nearly all observed values were within the boundaries of NACW.

North Atlantic deep and bottom water (NADW) is defined to fall between temperatures of 3.5° and 2.2°C and salinities of 34.97 and 34.90 o/oo (Sverdrup, 1942), usually at depths below 3000 m. From approximately 1800 m to the bottom, station data were within the limits for NADW.

In the upper 100 m during periods of warming and cooling the shelf/slope water boundary can become indistinguishable in its temperature characteristics. From April through August surface shelf water increases in temperature until it becomes slightly greater than that of surface slope water. In September cooling begins. By March, shelf water temperatures are well below those of slope water (fig. 34). The shelf/slope water boundary can be further obscured by periods of high or low land runoff. These cause the salinity to decrease during high runoff and increase during low runoff. During the period of this cruise, some slope water was still warming and shelf water was warming to slope water temperatures.

In the top 100 m the temperature ranged between 7.7° and 21.7°C and the salinity between 32.75 and 36.15 o/oo. Temperature-salinity observations that were plotted to the left of a line drawn from salinity = 35.0 o/oo, temperature = 11°C and salinity = 34.0 o/oo, temperature = 14°C were classified as shelf water. Observations to the right of a line drawn from salinity = 35.25 o/oo, temperature = 12°C and salinity = 34.5 o/oo, temperature = 21°C were classified as slope water. Those points in between were classed as a transition mass between shelf and slope water (fig. 33).

Shelf water was found in the upper 50 m at station 1, the upper 70 m at station 21, and the upper 10 m at station 22. At about the 30-m depth for stations 1 and 21 a core of cold water appeared having temperatures of about 7° and 9°C, and salinities less than 34.5 and 34.0 o/oo, respectively (figs. 3, 7, 15).

Observations that were characteristic of the transition mass occurred below 50 m at station 1, above 30 m at station 5, and around 80 m at station 21 (fig. 3). These stations are all located near the shelf edge. Pools of this water were also found between 40 and 50 m at station 7, between 15 and 40 m at station 8, and around 80 m at station 18 (figs. 5, 6, 12, 13). The remainder of the observations above 350 m, except that portion characteristic of the warm eddy, were within the defined boundary of slope water.

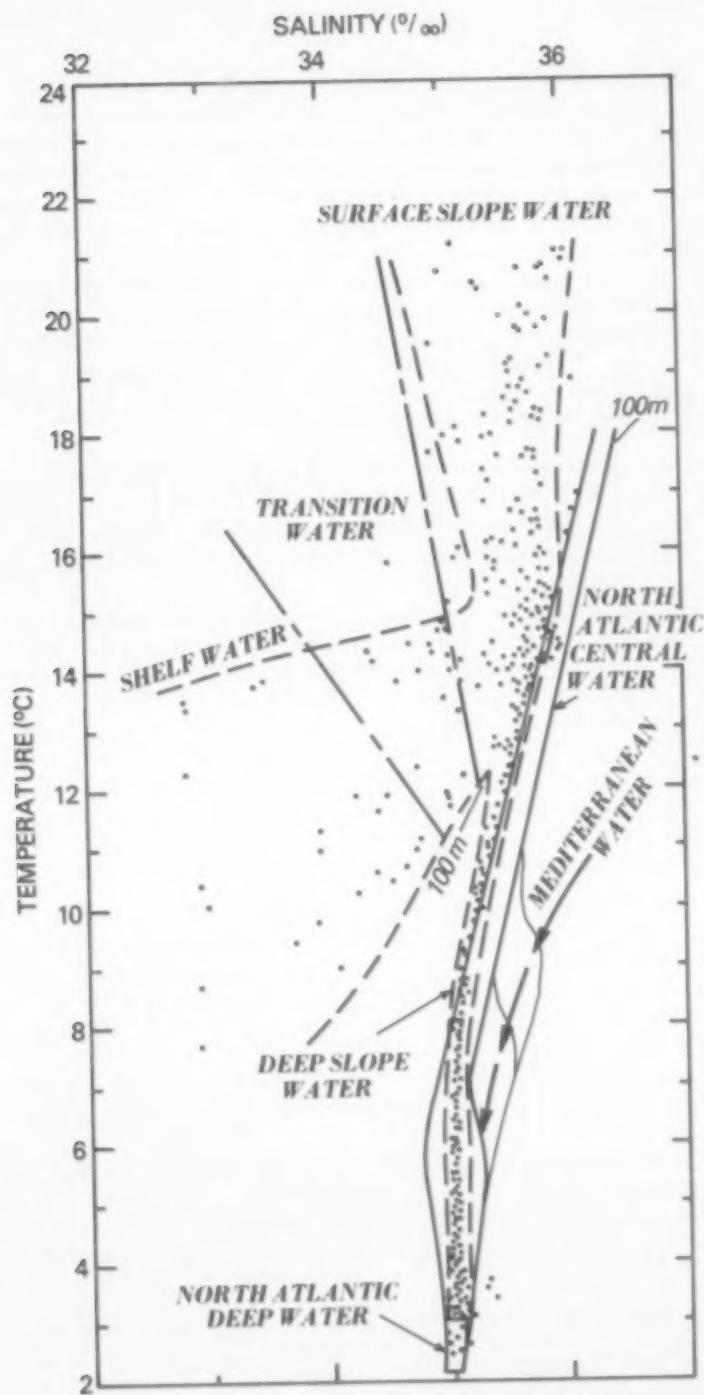


Figure 33.--Temperature-salinity relations for DWD 106 (dashed lines) from data for Albatross IV cruise May 1974.

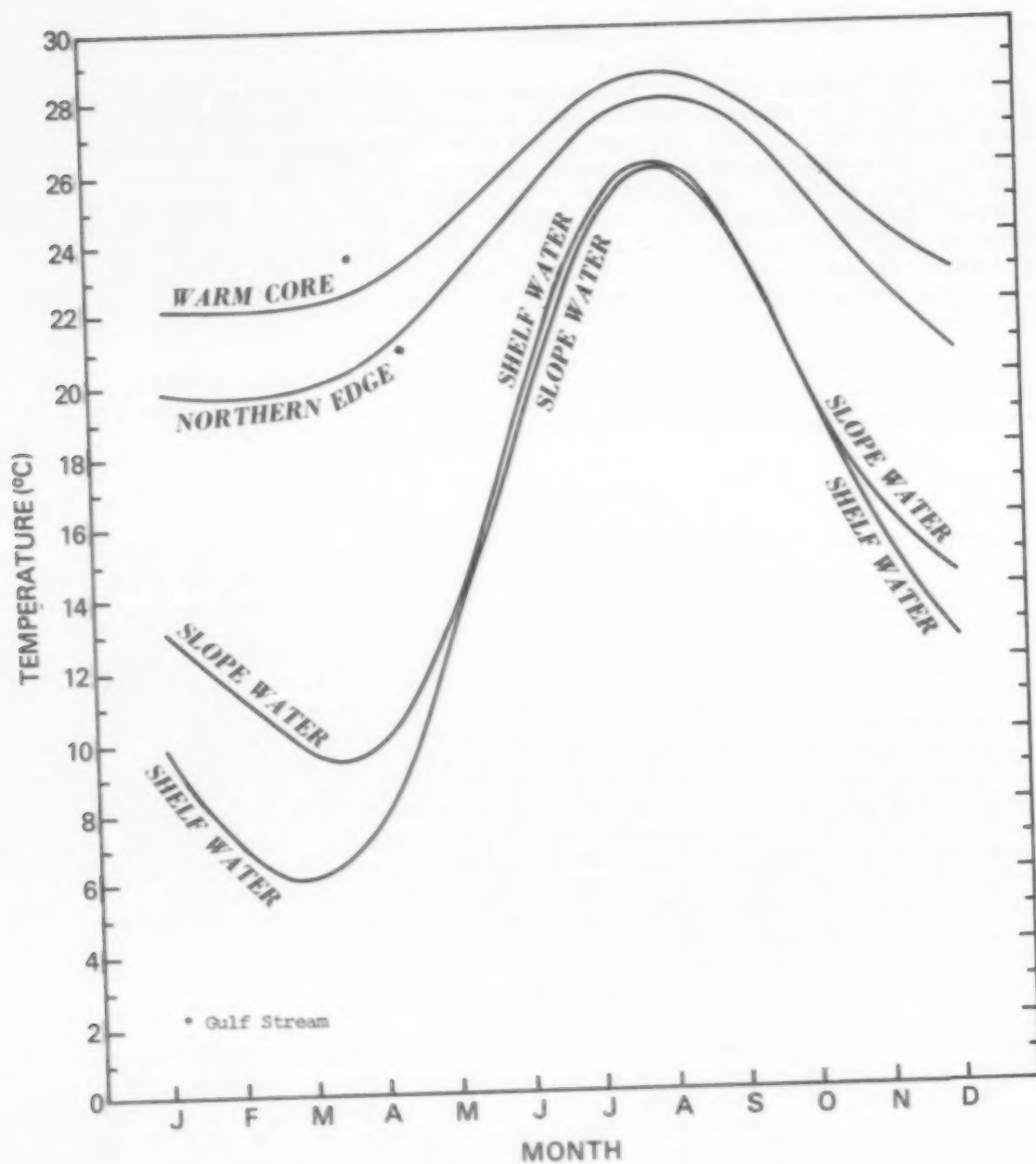


Figure 34.--Mean monthly sea surface temperature by water mass (after Fisher 1973).

SUMMARY

The temperature, salinity, and oxygen data collected on the Albatross IV cruise appeared to be consistent with historical data. The upper 100 m, where shelf water intrudes into and mixes with slope water, can be highly variable. The predominant water masses found in the DWD-106 area were identified as follows: 1) shelf water and slope water in the upper 100 m, 2) water slightly fresher than NACW between 100 m and 350 m, 3) NACW below 350 m to about 1800 m, and 4) NADW from 1800 m to the bottom. A portion of a warm eddy was found between 50 and 350 m in the vicinity of the dump-site. The temperature-salinity data for this water were within the limits for NACW.

The data presented here are a small portion of the overall picture. Seasonal studies of physical and chemical data can yield much information concerning water mass identification and circulation.

ACKNOWLEDGMENTS

Special thanks and appreciation are expressed to the following: Merton Ingham for advice and help in preparing this report; Steve Cook and other members of the Atlantic Environmental Group for preparation and participation in the cruise; Iona Black for help on the cruise and the many hours of data processing; representatives of the Environmental Protection Agency, Lamont-Doherty Geological Observatory of Columbia University, and, within NOAA, the Environmental Data Service's National Oceanographic Data Center, the National Marine Fisheries Service's Northeast Fisheries Center, Systematics Laboratory, and crew of the Albatross IV for participation in collecting the data; the U.S. Coast Guard Oceanographic Unit for use of equipment and computer facilities; Nat Corwin of Woods Hole Oceanographic Institution for advice and equipment for oxygen analysis. The National Oceanographic Data Center for processing XBT data; Ken Warsh for processing the hydrographic and STD data; and E. P. Dagher of NOAA Environmental Satellite Service's Environmental Products Group for satellite photographs of sea-surface temperature data.

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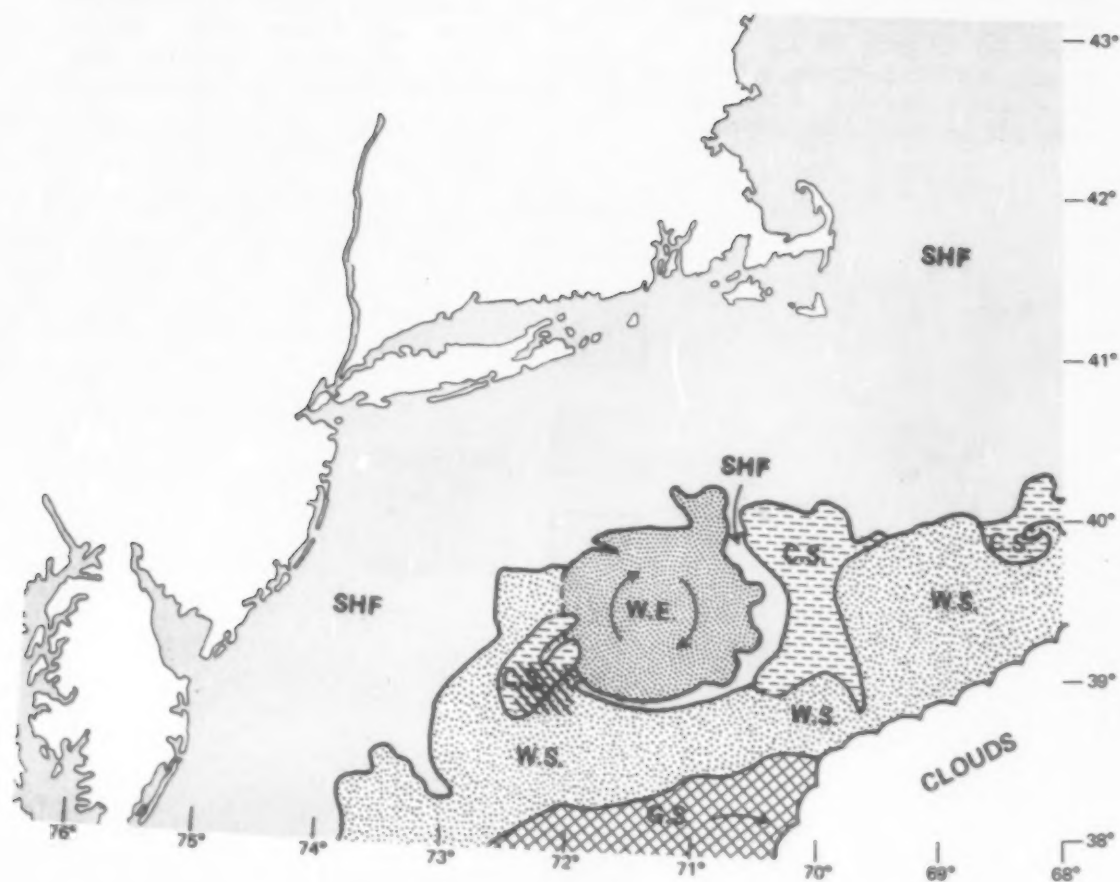
APPENDIX A.--NOAA National Environmental Satellite Service observations of Shelf, Slope, and Gulf Stream waters, May 13-21, 1974.

Charts prepared from satellite imagery depict surface watermass boundaries and the inception, movement, and dissipation of eddies over the continental shelf and slope in the vicinity of Deepwater Dumpsite 106. The satellite photographs were taken by NOAA-3 very high resolution radiometer infrared (VHRR-IR) imagery on 13, 14, 15, 16, 17, 19, 20, and 21 May 1974. Shelf, Slope, and Gulf Stream waters are mapped. Slope Waters are differentiated into cold-slope and warm-slope waters whenever possible. Warm tongues and warm eddies are also mapped.

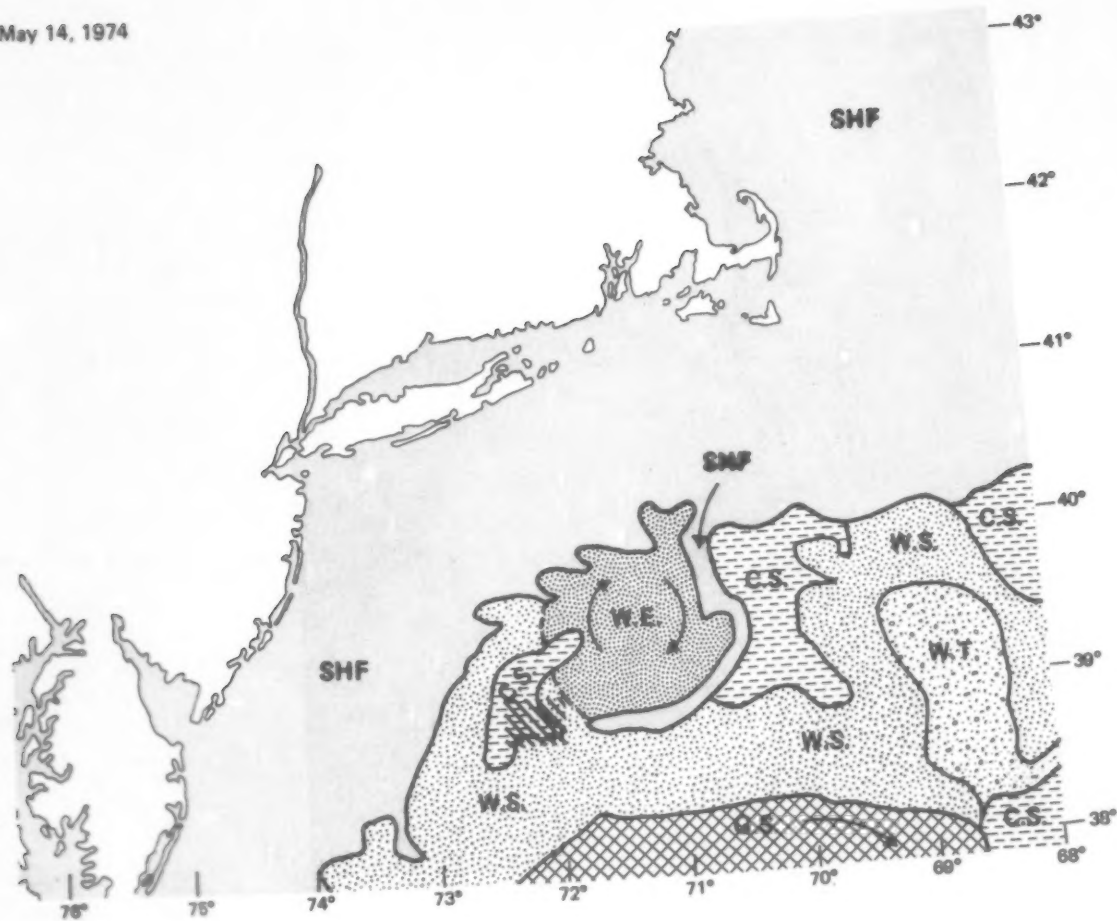
LEGEND

SHF		SHELF WATER
C.S.		COLD SLOPE
W.S.		WARM SLOPE
Sl.W.		SLOPE
W.T.		WARM TONGUE
G.S.		GULF STREAM
W.E.		WARM EDDY

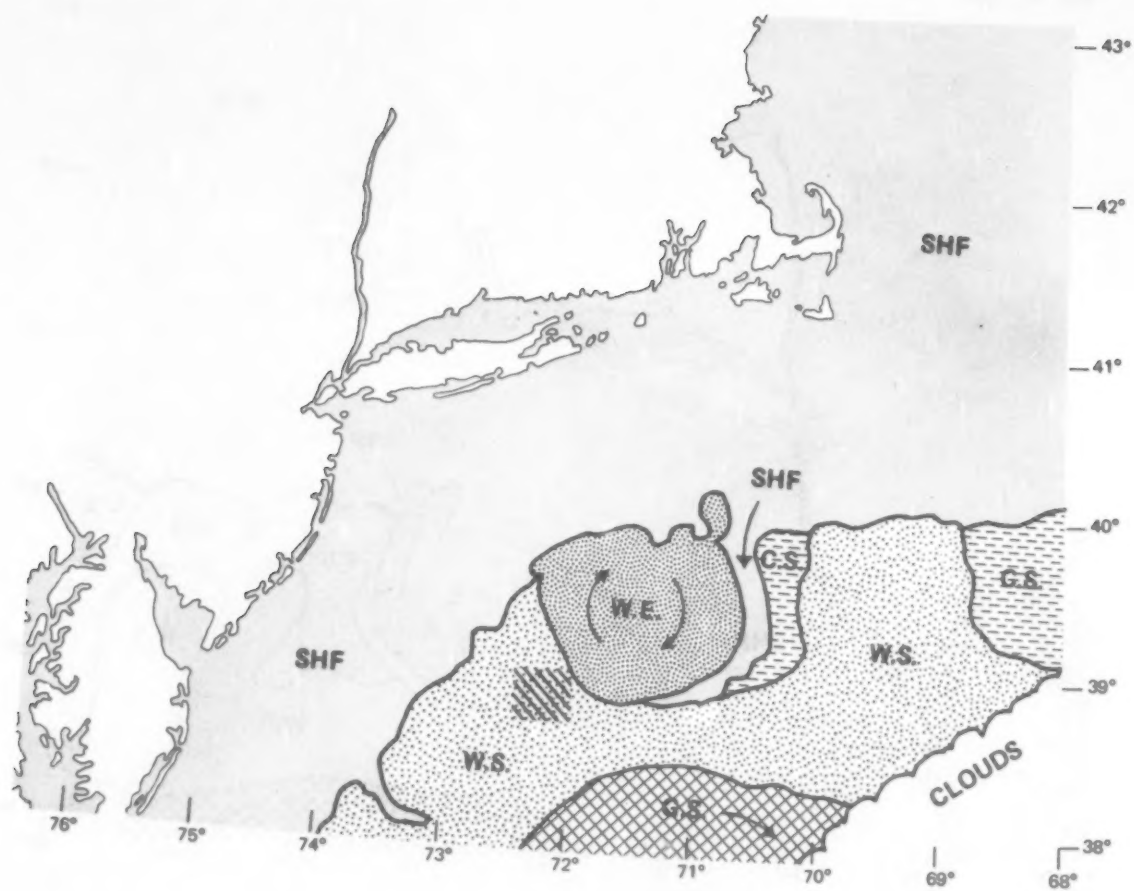
May 13, 1974



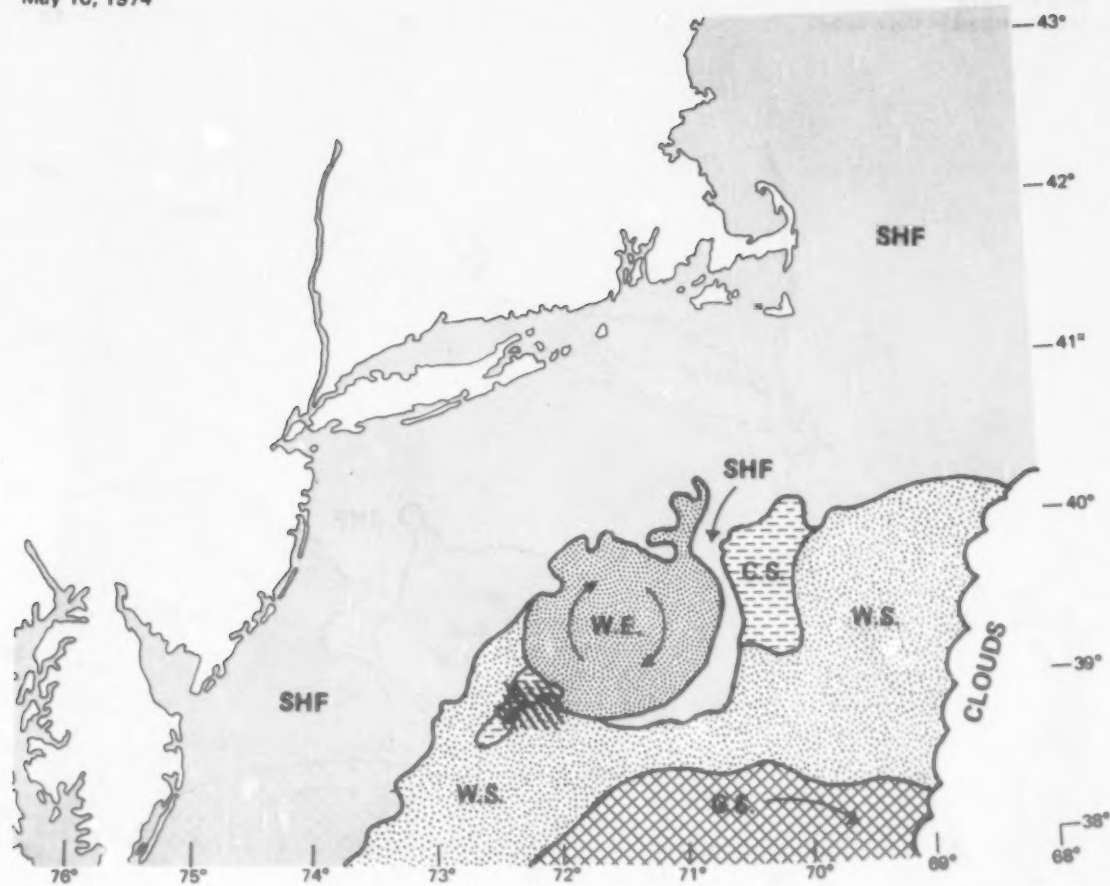
May 14, 1974



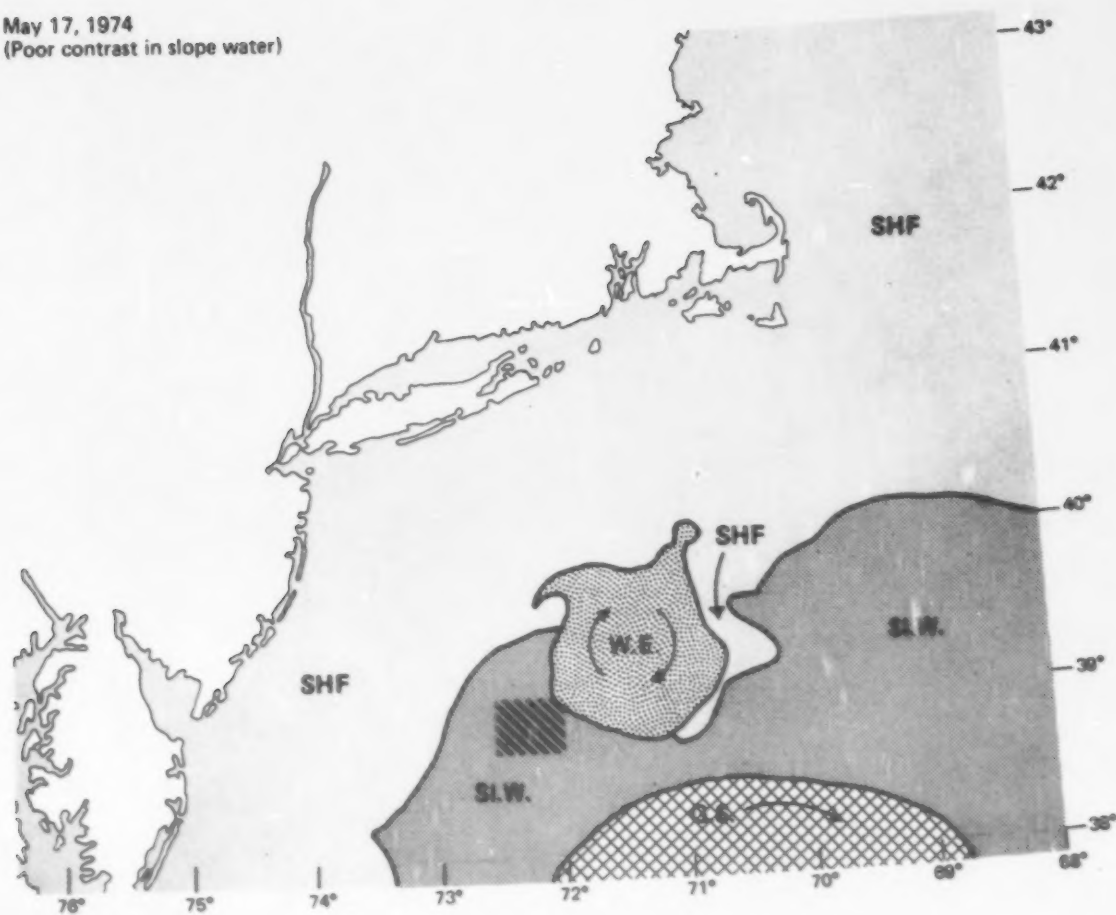
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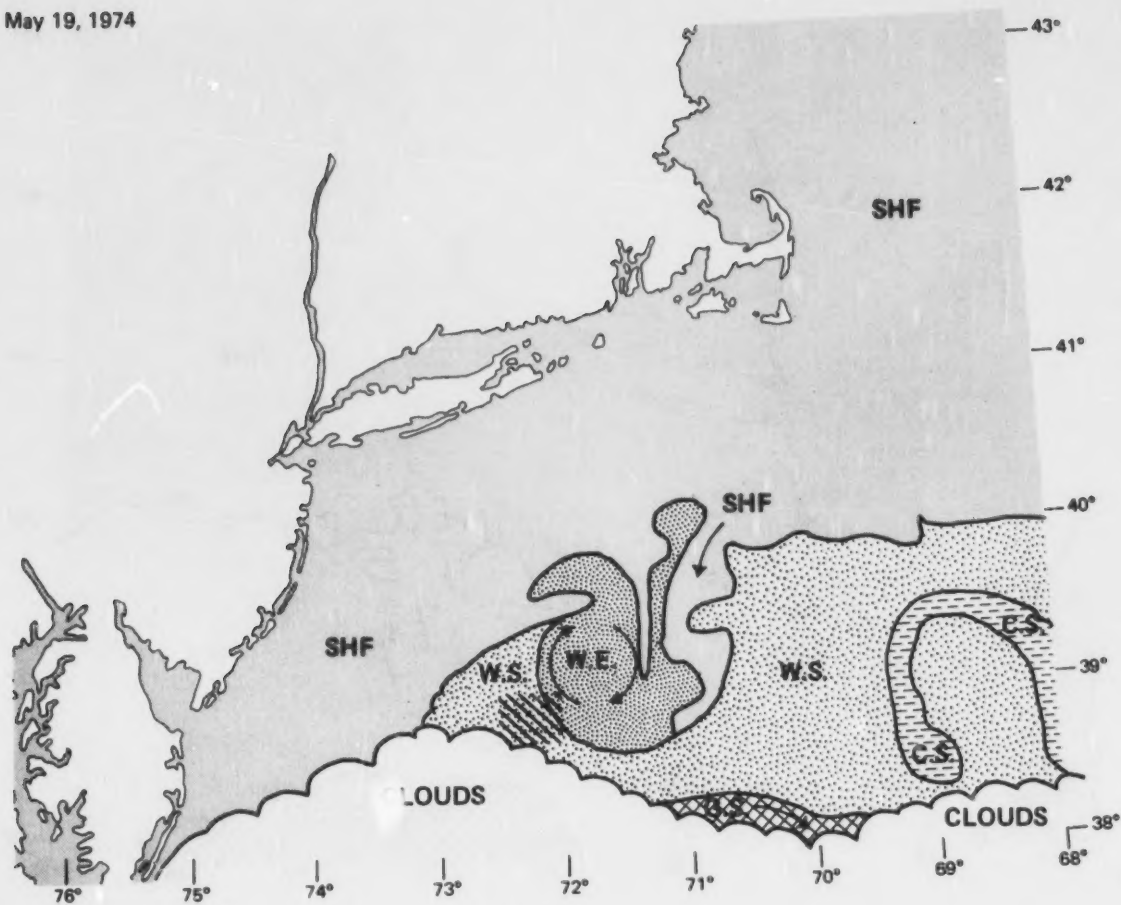
May 16, 1974



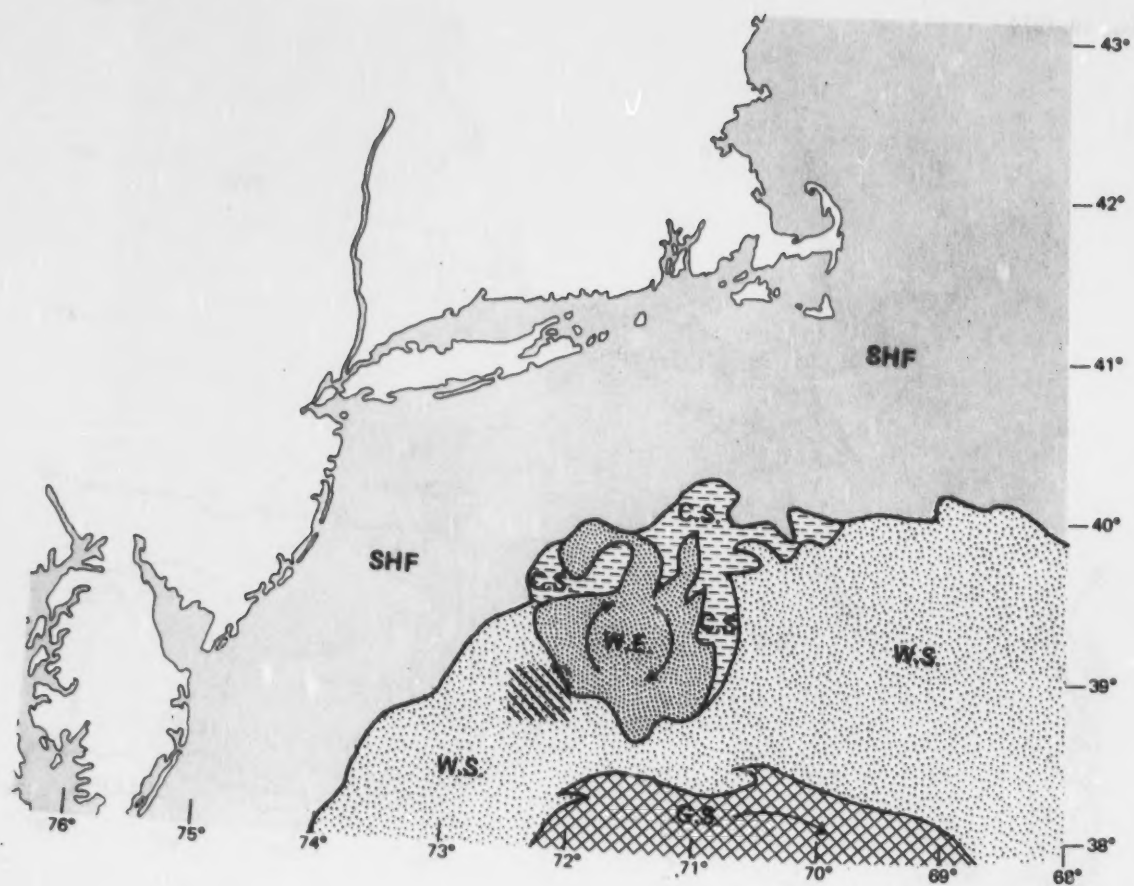
May 17, 1974
(Poor contrast in slope water)



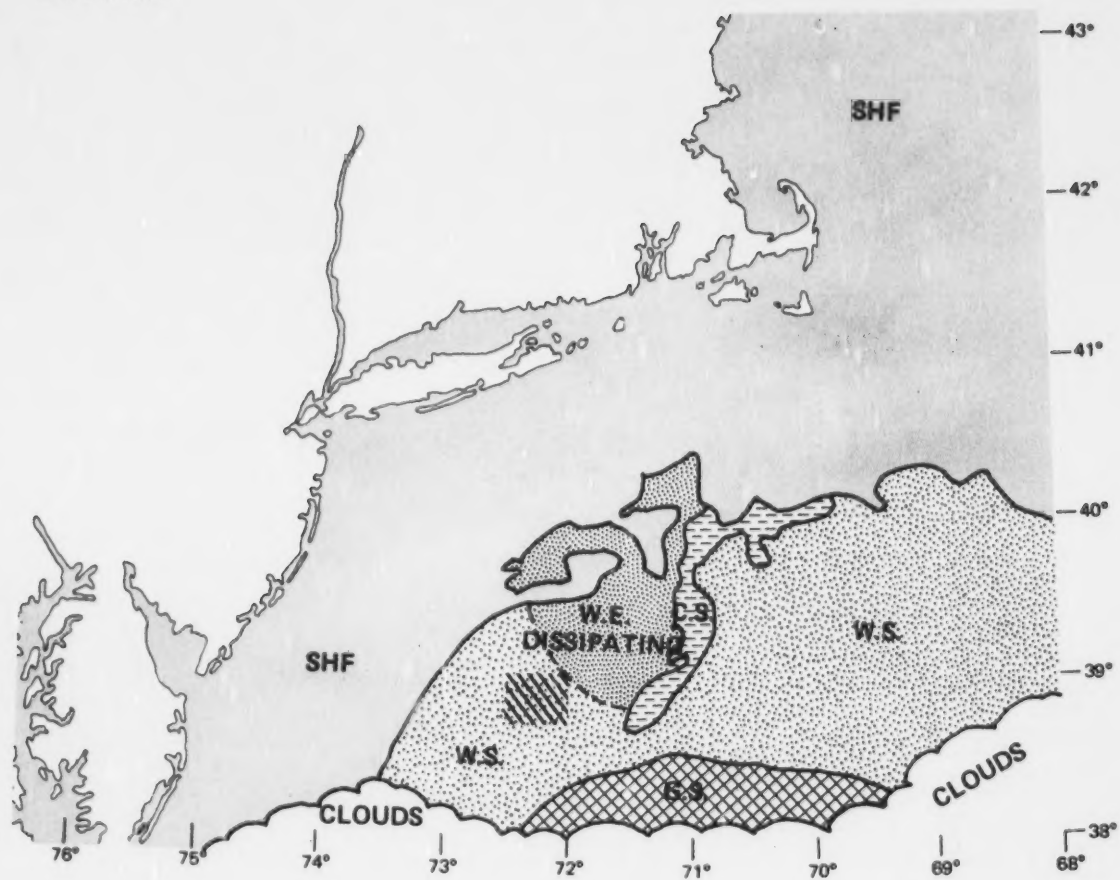
May 19, 1974



May 20, 1974



May 21, 1974



MICRONUTRIENT ANALYSIS OF SEAWATER SAMPLES TAKEN AT DEEPWATER

DUMPSITE 106--MAY 1974

Harold Petersen

NOAA, National Marine Fisheries Service
MARMAP Field Group, Narragansett, R.I.

INTRODUCTION

Seawater samples were collected at Deepwater Dumpsite 106 by the National Marine Fisheries Service (NMFS) vessel Albatross IV during May 10-23, 1974. Samples were collected and stored aboard the Albatross IV by the Atlantic Environmental Group (NMFS). Samples were obtained without filtration from STD (salinity-temperature-density) and hydrographic casts and stored in 250-ml screwcap polycarbonate and polypropylene bottles in the vessel's freezer (ca. -20°C). Upon completion of the cruise, samples were transferred to a shoreside freezer and maintained at -20°C except for analysis.

ANALYSIS PROCEDURE

Prior to analysis, samples were thawed and brought to room temperature. They were then well shaken to assure proper mixing of brine with the remainder of the bottle contents.

Analyses were carried out using a Technicon Auto Analyzer II for nitrate, silicate, ammonia, and orthophosphate content. In a typical analysis sequence, standards were run for instrument calibration immediately prior to and immediately following analyses of the samples.

In several instances, duplicate samples were taken in bottles made of polycarbonate, and in other instance, duplicates were taken with one sample stored in a polycarbonate bottle and a second in a polypropylene bottle. No duplicate samples were taken where both samples were stored in polypropylene bottles.

It was expected that some sample decomposition would occur (even when the samples were maintained at -20°C) due to sample interaction with the container, or sample contamination resulting from biological activity, or from both of these possibilities and others as well. Therefore, to examine this possibility, several samples were analyzed up to four times over a period of 97 days from the time the sample was taken. Every sample was analyzed at least twice.

RESULTS AND DISCUSSION

A comparison of the magnitude of differences in concentrations obtained for duplicate samples with the estimated error inherent in the analysis shows that extremely precise values have been obtained. There does not appear to be any effect of bottle type on this result.

Repeat analyses of several samples confirmed suspicions that some of the micronutrient concentrations vary with time. These variations include a decrease in phosphate concentration and an increase in nitrate concentration with time. Silicate concentrations remain constant over the same period. Ammonia concentrations vary, sometimes increasing and sometimes decreasing with time.

The rate of change of sample composition with time was not found to be sufficiently constant to allow calculation of a correction factor of the form " $\pm$ xx $\mu\text{g-at/liter/day}$ change," hence it was not possible to extrapolate observed values back to the time the samples were taken. The values included in this listing are those corresponding to the earliest date at which the analyses were made. As a very rough guide, nitrates in the range of 10 to 20 $\mu\text{g-at N/liter}$ are approximately 1 $\mu\text{g-at N/liter}$ high (less at concentrations below this range); phosphates in the range 1 to 2 $\mu\text{g-at P/liter}$ are approximately 0.4 $\mu\text{g-at P/liter}$ low (less at concentrations below this range); and ammonias in the range 0.5 to 1.0 $\mu\text{g-at N/liter}$ vary by approximately 0.15 $\mu\text{g-at N/liter}$.

These results indicate the need to complete analyses in a real-time frame if at all possible when using unfiltered samples. While the effect of filtration on long-term sample integrity was not observed, it is anticipated that filtering the samples, and thereby removing biological organisms prior to storage, would result in a slower rate of sample decomposition than observed, and would provide more accurate analyses of stored samples.

Table 1.--Micronutrient concentrations in samples taken by RV Albatross
IV during May 1974 survey of Deepwater Dumpsite 106.

All concentrations are given in microgram-atoms per liter, depths in meters, and dates (day, month, year) in GMT. For each sample, "S" indicates an STD cast, "H" indicates a hydro cast, followed by the sample depth.

		NITRATE	SILICATE	AMMONIA	PHOSPHATE
Station:	1				
Date:	100574				
Latitude:	39°00'N				
Longitude:	73°00'W				
S	1	0.48	1.82	1.41	0.81
S	15	0.21	1.49	1.43	0.82
S	50	9.62	6.94	1.52	1.04
S	65	9.67	7.00	1.43	0.96
S	72	9.88	6.84	1.44	1.04
Station:	2				
Date:	110574				
Latitude:	38°50'N				
Longitude:	72°46'W				
S	0	0.15	1.21	--	0.32
S	15	0.92	1.48	0.51	0.34
S	50	12.35	5.11	0.50	0.87
S	100	13.66	5.55	0.38	0.94
S	200	21.60	11.63	0.42	1.47
S	300	25.92	16.24	0.34	1.80
S	500	19.94	13.14	0.47	1.45
S	700	18.97	13.01	0.45	1.39
S	900	18.74	12.26	0.49	1.38
S	1100	16.53	10.99	0.57	1.25
S	1500	18.42	13.54	0.63	1.71

NITRATE SILICATE AMMONIA PHOSPHATE

Station: 4
Date: 130574
Latitude: 38°40'N
Longitude: 73°00'W

		0.07	1.20	1.37	0.33
S	1	1.26	1.89	1.37	0.37
S	15	14.39	6.15	1.32	0.97
S	50	14.49	6.27	1.32	1.03
S	100	26.91	16.88	1.27	1.83
S	200	25.75	14.57	1.31	1.73
S	300	20.93	13.50	1.28	1.48
S	500	20.54	12.83	1.27	1.44
S	700	20.01	12.61	1.27	1.40
S	900	19.62	11.38	1.26	1.37
S	1100	20.01	12.52	1.25	1.36
S	1101				

Station: 5
Date: 150574
Latitude: 39°10'N
Longitude: 72°45'W

		0.06	0.92	0.86	0.76
S	1	0.07	0.87	0.87	0.85
S	15	6.22	2.65	0.86	0.72
S	50	10.69	7.23	0.82	1.00
S	100	9.40	8.03	0.84	1.09
S	110				

Station: 6
Date: 160574
Latitude: 39°00'N
Longitude: 72°30'W

		0.09	0.92	0.48	1.41
S	1	0.15	1.01	0.51	1.37
S	15	1.82	1.46	0.70	1.54
S	50	11.13	4.43	0.47	1.96
S	100	18.46	8.54	0.44	2.42
S	200	25.70	15.37	0.45	2.92
S	300	21.40	13.92	0.42	2.70
S	500	19.10	12.51	0.42	2.56
S	700	18.62	12.01	0.45	2.49
S	900	18.14	12.30	0.49	2.49
S	1100	18.55	12.58	0.50	2.47
S	1300	18.51	14.20	0.54	2.45
S	1350				

Station: 7
 Date: 160574
 Latitude: 38°55'N
 Longitude: 72°22'W

	NITRATE	SILICATE	AMMONIA	PHOSPHATE
S 1	0.12	1.27	0.50	0.71
S 15	0.20	1.58	0.56	0.78
S 50	1.04	1.31	0.61	0.96
S 100	10.30	4.65	0.52	1.14
S 200	11.30	6.38	0.54	1.13
S 300	24.46	15.50	0.52	2.02
S 500	20.86	14.97	0.55	1.83
S 700	18.87	13.78	0.59	1.72
S 900	17.87	13.36	0.55	1.66
S 1100	18.06	13.42	0.56	1.64
H 1262	18.40	12.46	0.58	2.49
S 1300	17.62	13.90	0.55	1.64
H 1464	18.27	13.41	0.55	2.47
S 1500	17.86	12.91	0.52	1.67
H 1566	18.14	13.99	0.55	2.49
H 1768	18.08	14.26	0.54	2.48
H 1969	17.89	14.24	0.55	2.47
H 2110	18.41	14.99	0.57	2.50

Station: 8
 Date: 160574
 Latitude: 38°50'N
 Longitude: 72°15'W

	NITRATE	SILICATE	AMMONIA	PHOSPHATE
S 1	0.28	1.44	0.27	1.47
S 15	21.08	14.43	0.23	2.66
S 50	3.79	2.66	0.57	1.69
S 100	8.22	2.98	0.19	1.77
S 200	22.35	12.09	0.16	2.64
S 300	24.81	16.19	0.13	2.91
S 500	20.17	13.92	0.21	2.70
S 700	18.19	12.47	0.20	2.54
S 900	17.22	12.02	0.14	2.44
H 1027	18.49	--	0.27	2.64
S 1100	17.46	12.17	0.17	2.47
H 1206	18.24	10.93	0.38	2.61
H 1296	18.13	11.15	0.31	2.61
S 1300	17.40	12.49	0.17	2.43
H 1477	18.21	11.36	0.35	2.67
S 1500	17.58	12.93	0.19	2.42
H 1666	18.15	12.37	0.38	2.62
H 1850	18.36	14.04	0.39	2.59
H 2041	18.24	14.56	0.41	2.60
H 2233	18.45	12.12	0.46	2.59

Station: 9
Date: 170574
Latitude: 38°45'N
Longitude: 72°07'W

	NITRATE	SILICATE	AMMONIA	PHOSPHATE
S 1	0.14	1.02	0.42	0.66
S 15	0.24	0.79	0.40	0.90
S 50	2.72	1.39	0.44	0.84
S 100	11.43	4.54	0.39	1.16
S 200	21.65	11.96	0.40	1.87
S 300	24.39	15.82	0.36	2.10
S 500	19.39	13.40	0.36	1.84
S 700	18.07	12.16	0.36	1.73
S 900	18.08	12.11	0.38	1.67
S 1100	17.65	12.18	0.42	1.66
H 1200	17.92	12.59	0.40	1.61
S 1300	17.85	12.66	0.38	1.69
H 1494	17.54	13.27	0.37	1.61
S 1500	19.40	13.32	0.41	1.69
H 1593	17.28	13.48	0.36	1.54
H 1787	17.56	14.16	0.38	1.59
H 2008	18.01	14.31	0.38	1.57
H 2172	17.51	16.88	0.39	1.60
H 2372	18.37	13.14	0.40	1.64

Station: 10
Date: 170574
Latitude: 38°40'N
Longitude: 72°00'W

	NITRATE	SILICATE	AMMONIA	PHOSPHATE
S 1	0.06	1.11	--	0.92
S 15	0.20	1.18	--	0.91
S 50	5.11	2.48	--	1.20
S 100	10.69	5.00	--	1.37
S 200	22.30	12.53	--	2.10
S 300	24.29	15.42	--	2.28
S 500	19.45	13.42	--	1.99
S 700	17.73	12.59	--	1.89
S 900	16.96	12.30	--	1.85
S 1100	17.60	12.56	--	1.88
S 1300	17.27	12.89	--	1.86
H 1391	16.92	13.13	0.41	1.78
S 1500	17.66	13.52	--	1.84
H 1591	16.49	13.60	0.43	1.78
H 1691	16.81	14.13	0.42	1.77
H 1891	16.94	14.90	0.43	1.79
H 2091	16.62	15.01	0.43	1.79
H 2291	16.50	17.54	0.44	1.77
H 2491	16.57	16.85	0.43	1.80
H 2691	16.51	14.65	0.41	1.79

Station: 11
 Date: 180574
 Latitude: 39°00'N
 Longitude: 72°00'W

	NITRATE	SILICATE	AMMONIA	PHOSPHATE
S 1	0.01	0.35	0.53	1.59
S 15	0.94	1.19	0.55	1.67
S 50	4.71	1.78	0.57	1.56
S 100	7.67	3.11	0.55	1.49
S 200	7.71	3.23	0.55	1.49
S 300	8.04	3.77	0.54	1.44
S 500	22.08	14.53	0.50	2.35
S 700	19.90	13.21	0.51	2.22
S 900	18.32	12.32	0.51	2.18
S 1100	18.44	12.28	0.48	2.14
H 1144	18.29	12.05	0.41	2.22
S 1300	18.08	12.36	0.51	2.14
H 1335	17.90	12.13	0.41	2.18
H 1433	18.10	12.22	0.42	2.15
S 1500	18.06	13.11	0.54	2.15
H 1626	18.17	12.05	0.42	2.14
H 1832	16.71	11.64	0.43	2.06
H 2042	18.18	15.05	0.45	2.12

Station: 12
 Date: 180574
 Latitude: 38°55'N
 Longitude: 72°07'W

	NITRATE	SILICATE	AMMONIA	PHOSPHATE
S 1	0.02	0.40	0.61	0.93
S 15	0.25	0.61	0.50	0.92
S 50	2.27	1.01	0.48	0.72
S 100	7.73	3.23	0.47	0.87
S 200	8.51	3.63	0.47	0.93
S 300	13.14	5.92	0.47	1.37
S 500	22.56	14.71	0.46	1.96
S 700	19.75	13.41	0.42	1.82
S 900	18.28	12.12	0.42	1.79
S 1100	18.27	12.27	0.49	1.73
S 1300	18.07	12.61	0.53	1.80
S 1305	18.95	12.22	0.26	1.82
H 1502	18.56	12.86	0.26	1.79
H 1601	18.51	13.25	0.25	1.74
H 1798	18.47	13.47	0.25	1.72
H 1995	17.87	12.42	0.30	1.75
H 2192	18.58	16.58	0.27	1.71
H 2389	17.64	13.80	0.28	1.67
H 2438	17.87	13.12	0.30	1.69

Station: 13
 Date: 190574
 Latitude: 38°45'N
 Longitude: 72°23'W

	NITRATE	SILICATE	AMMONIA	PHOSPHATE
S 1	0.04	1.20	0.24	0.70
S 15	0.76	1.71	0.27	0.92
S 50	5.23	3.35	0.45	1.05
S 100	7.69	3.98	0.23	1.05
S 200	12.48	10.60	0.20	1.73
S 300	15.59	15.95	0.21	2.11
S 500	12.08	13.30	0.20	1.81
S 700	11.18	12.55	0.21	1.81
S 900	11.53	12.11	0.24	2.02
S 1100	11.42	12.17	0.26	1.76
S 1300	11.55	12.67	0.28	1.75
H 1320	17.25	13.09	0.38	1.72
S 1500	11.45	13.05	0.30	1.73
H 1507	16.90	13.40	0.33	1.71
H 1603	16.82	13.89	0.27	1.73
H 1787	16.88	14.38	0.32	1.79
H 1972	17.08	14.62	0.41	1.76
H 2150	17.20	16.93	0.38	1.84
H 2283	17.33	15.79	0.36	2.08

Station: 14
 Date: 190574
 Latitude: 38°40'N
 Longitude: 72°30'W

	NITRATE	SILICATE	AMMONIA	PHOSPHATE
S 1	0.05	0.80	0.35	0.61
S 15	0.07	0.84	0.37	0.68
S 50	0.29	0.49	0.48	0.61
S 100	12.40	6.16	0.32	1.12
S 200	22.21	13.76	0.24	1.83
S 300	22.59	15.66	0.29	1.95
S 500	19.00	13.27	0.25	1.66
S 700	17.75	13.63	0.32	1.53
S 900	16.98	12.38	0.35	1.55
S 1100	16.87	12.55	0.33	1.55
H 1287	17.41	13.14	0.32	1.71
S 1300	16.70	12.85	0.32	1.56
H 1459	17.14	13.91	0.27	1.76
S 1500	17.02	13.60	0.34	1.57
H 1549	17.34	14.18	0.29	1.67
H 1927	17.27	15.07	0.22	1.65
H 1911	17.13	14.60	0.21	1.64
H 2096	17.33	17.10	0.33	1.86
H 2244	17.19	13.72	0.34	1.88

Station: 15
 Date: 200574
 Latitude: 38°30'N
 Longitude: 72°15'W

		NITRATE	SILICATE	AMMONIA	PHOSPHATE
S	1	0.05	1.16	0.76	0.25
S	15	0.12	1.25	0.78	0.25
S	50	0.32	1.52	0.90	0.69
S	100	14.02	6.17	0.79	1.35
S	200	21.47	12.04	0.77	1.95
S	300	24.78	16.45	0.75	2.16
S	500	19.03	12.77	0.76	1.72
S	700	17.75	12.08	0.74	1.65
H	840	17.26	11.78	--	1.76
S	900	16.93	11.57	0.75	1.64
H	987	17.60	11.93	--	1.68
H	1056	17.05	12.08	--	1.76
S	1100	17.24	12.06	0.73	1.60
H	1200	17.46	12.66	--	1.78
S	1300	16.96	12.30	0.79	1.59
H	1348	17.52	12.69	--	1.78
S	1500	17.01	12.84	0.80	1.58
H	1507	17.18	13.50	--	1.78
H	1663	17.58	13.41	--	1.73
H	1846	18.00	11.45	--	1.73
H	1964	17.30	16.07	--	1.73

Station: 16
 Date: 200574
 Latitude: 38°20'N
 Longitude: 72°00'W

		NITRATE	SILICATE	AMMONIA	PHOSPHATE
S	1	0.05	2.45	0.04	1.25
S	15	1.00	2.18	0.15	1.32
S	50	6.72	3.84	--	1.39
S	100	16.56	8.38	--	1.63
S	200	22.90	13.88	--	2.29
S	300	26.02	18.33	0.01	2.45
S	500	19.62	13.25	0.04	2.08
S	700	17.80	12.02	0.10	2.00
S	900	17.11	12.28	0.35	1.90
S	1100	17.29	12.31	0.35	1.85
S	1300	17.47	12.69	0.25	1.72
H	1362	17.09	12.63	0.25	1.56
S	1500	17.31	13.23	--	1.71
H	1560	16.58	13.41	0.29	1.67
H	1660	16.73	14.20	0.23	1.58
H	1758	16.55	15.05	0.33	1.62

		NITRATE	SILICATE	AMMONIA	PHOSPHATE
H	2056	17.14	15.12	0.47	1.63
H	2257	16.51	17.34	0.50	1.53
H	2454	16.72	15.56	0.56	1.70
H	2658	18.40	13.42	0.49	1.68
H	2830	16.17	22.06	0.54	1.73

Station: 17
 Date: 210574
 Latitude: 38°32'N
 Longitude: 71°44'W

S	1	0.07	1.06	--	1.12
S	15	2.11	1.54	--	1.20
S	50	4.47	2.36	--	1.15
S	100	10.93	5.34	--	1.60
S	200	20.79	12.78	--	2.38
S	300	23.73	17.10	--	2.57
S	500	19.25	14.10	--	2.16
S	700	17.73	12.67	--	2.08
S	850	17.18	12.69	--	2.05
S	1100	17.47	12.71	--	1.94
S	1300	16.91	12.85	--	1.96
H	1339	16.12	13.56	0.06	1.99
S	1500	17.20	13.51	--	2.06
H	1531	16.41	14.37	--	1.88
H	1628	16.05	14.92	--	2.08
H	1823	16.23	15.47	--	1.96
H	2020	16.41	16.86	--	1.83
H	2216	15.93	18.32	--	1.90
H	2742	15.63	21.39	0.01	1.77

Station: 18
 Date: 210574
 Latitude: 38°40'N
 Longitude: 71°30'W

S	1	0.01	0.83	0.42	0.97
S	15	0.17	1.39	0.41	0.86
S	100	11.96	6.28	0.42	1.43
S	200	19.92	12.38	0.42	1.98
S	300	23.44	16.64	0.39	2.27
S	500	17.94	13.96	0.41	2.41
S	700	16.98	12.74	0.44	2.30
S	900	16.26	12.68	0.50	2.34
S	1100	16.06	12.93	0.50	2.38
S	1300	16.09	13.77	0.48	1.72

		NITRATE	SILICATE	AMMONIA	PHOSPHATE
H	1305	13.44	13.91	--	1.92
S	1500	16.59	13.89	0.61	1.74
H	1504	13.38	14.62	--	2.00
H	1604	13.44	15.39	--	2.01
H	1803	13.51	15.79	--	1.96
H	2002	13.76	15.32	--	2.19
H	2201	13.63	18.35	--	1.87
H	2400	13.25	19.72	--	1.77
H	2600	14.26	14.79	--	1.86
H	2688	13.07	22.79	--	1.80

Station: 19
 Date: 220574
 Latitude: 38°50'N
 Longitude: 71°45'W

S	1	0.18	0.94	0.62	0.91
S	15	10.12	5.66	0.57	1.33
S	50	2.73	2.61	0.92	1.01
S	100	7.47	3.54	0.58	1.12
S	200	7.72	3.61	0.54	1.12
S	300	20.63	12.66	0.51	2.03
S	500	20.45	15.66	0.50	2.07
S	700	17.54	13.29	0.53	1.88
S	900	16.34	12.50	0.52	1.83
S	1100	16.34	12.51	0.54	1.86
S	1300	16.28	12.64	0.57	1.84
H	1346	17.61	12.92	0.70	1.65
S	1500	16.66	13.19	--	1.85
H	1544	17.67	13.57	0.67	1.64
H	1642	17.68	13.99	0.77	1.64
H	1840	17.55	14.70	0.80	1.67
H	2037	17.17	14.66	0.79	1.69
H	2234	17.30	17.51	0.78	1.67
H	2432	16.04	14.46	0.76	1.61
H	2545	17.24	16.56	0.81	1.73

Station: 20
 Date: 220574
 Latitude: 39°10'N
 Longitude: 72°15'W

S	1	0.02	0.74	0.72	0.67
S	15	0.07	0.75	0.71	0.60
S	50	3.98	1.43	0.71	0.80
S	100	6.92	3.03	0.71	0.83

		NITRATE	SILICATE	AMMONIA	PHOSPHATE
S	200	7.67	3.71	0.69	0.86
S	300	16.43	8.32	0.69	1.35
S	400	23.57	15.82	0.67	1.93
S	500	20.85	14.52	0.69	1.79
S	600	19.15	13.27	0.72	1.65
S	700	18.83	12.82	0.70	1.68
S	701	18.76	12.77	0.70	1.62
S	702	18.76	12.77	0.73	1.65

Station: 21
 Date: 220574
 Latitude: 39°20'N
 Longitude: 72°30'W

S	5	0.01	1.00	0.84	1.65
S	15	0.03	1.17	0.88	1.54
S	50	6.31	7.12	1.23	1.35
S	100	13.46	8.53	0.94	1.46
S	125	16.25	10.27	0.95	1.63

Station: 22
 Date: 230574
 Latitude: 39°20'N
 Longitude: 72°01'W

S	1	0.08	0.85	0.47	1.12
S	15	0.16	1.02	0.50	1.26
S	50	3.88	1.93	0.59	0.95
S	100	6.86	3.35	0.58	1.06
S	200	8.19	4.21	0.52	0.94
S	300	22.49	15.16	0.50	1.42
S	500	19.51	14.01	0.48	1.74
S	700	18.63	12.97	0.49	1.67
S	900	17.94	12.68	0.49	1.63
S	1100	18.09	12.56	0.53	1.61
S	1300	17.84	12.66	0.52	1.60
S	1350	18.12	12.71	0.51	1.65

	NITRATE	SILICATE	AMMONIA	PHOSPHATE
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Station: 23
 Date: 230574
 Latitude: 39°10'N
 Longitude: 71°46'W

S	1	0.05	0.79	0.60	0.69
S	15	0.30	0.49	0.61	0.77
S	50	6.05	2.42	0.59	0.88
S	100	7.71	3.56	0.57	0.91
S	200	9.72	3.63	0.56	0.88
S	300	7.72	3.87	0.54	0.92
S	500	21.80	15.66	0.61	1.92
S	700	17.45	12.84	0.59	1.61
S	900	16.94	12.48	0.63	1.59
S	1100	16.67	12.42	0.65	1.62
H	1217	16.98	12.06	0.63	1.67
S	1300	16.45	12.43	0.66	1.62
H	1389	16.74	12.55	0.63	1.63
H	1475	16.68	12.88	0.62	1.63
S	1500	16.46	12.97	0.65	1.61
H	1646	16.50	12.93	0.62	1.65
H	1815	14.96	10.30	0.66	1.56
H	1982	16.67	15.43	0.63	1.64

ANALYTICAL RESULTS FOR WATER-COLUMN SAMPLES COLLECTED
AT DEEPWATER DUMPSITE 106--MAY 1974

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INTRODUCTION

The NOAA vessel Albatross IV collected water-column samples at 23 stations during the May 1974 survey of Deepwater Dumpsite 106. These samples were analyzed for total coliform bacteria, fecal coliform bacteria, heterotrophic marine bacteria, total Kjeldahl nitrogen (TKN), nitrate-nitrogen, total phosphorus, mercury, cadmium, zinc, copper, manganese, and lead. Methodology for developing the data and the results obtained are presented.

METHODOLOGY

Total Coliform Bacteria: The membrane filter technique using M-Endo Agar medium in 60 x 15 mm sterile plastic petri dishes was used to ascertain total coliform densities in seawater. Details of this procedure are given in Standard Methods For The Examination of Water and Wastewater, 13th edition, 1971, Section 408A, pp. 678-683.

Fecal Coliform Bacteria: Fecal coliforms were assayed by a membrane filter technique using MF-C Agar medium in 60 x 15 mm sterile plastic petri dishes with final incubation at $44.5 \pm 0.2^{\circ}\text{C}$ for 24 hours. Details of this procedure are provided in Standard Methods For The Examination of Water and Wastewater, 13th edition, 1971, Section 408B, pp. 684-685.

Heterotrophic Marine Bacteria: Marine Agar (2216 - Difco) according to the formula of Zobell (J. Mar. Res., 4:42, 1941) was used for the isolation, culture, and enumeration of heterotrophic marine bacteria. The conventional pour plate technique was used for enumeration. The inoculated plates were incubated at $20-22^{\circ}\text{C}$ for 7 days.

Total Kjeldahl Nitrogen (TKN): TKN was determined by the automated phenolate method (Technicon AutoAnalyzer) after manual digestion of the samples with Kel-Pac. Details of this procedure are found in Methods For Chemical Analysis of Water and Wastes, 1971, Environmental Protection Agency, pp. 157-169.

Nitrate-Nitrogen: Nitrate levels were determined by an automated system (Technicon AutoAnalyzer) in which brucine sulfate is reacted under very acidic conditions with nitrate. Details of this procedure are found in "Determination of Nitrate In Estuarine Waters, Automatic Determination Using a Brucine Method," Environ. Sci. Technol. 1:492-494, 1967.

Total Phosphorus: Total phosphorus was determined by the "Automated Single Reagent Method," as described in Methods For Chemical Analysis of Water and Wastes, 1971, Environmental Protection Agency, pp. 246-257.

Mercury: Mercury in seawater samples was determined by the cold-vapor flameless atomic absorption spectrophotometric technique. Details are described in Methods For Chemical Analysis of Water and Wastes, 1971, Environmental Protection Agency, pp. 121-130.

Cadmium, Zinc, Copper, Manganese, and Lead: Six liters of seawater were passed through Chelex-100 columns, eluting the retained metals with nitric acid and analyzing the metals in the eluate by atomic absorption spectrophotometry. Details of the procedure are found in "Chelating Resins for the Concentration of Trace Elements from Sea Water and Their Analytical Use in Conjunction with Atomic Absorption Spectrophotometry," J. P. Riley and D. Taylor, Anal. Chem. Acta., 1968, pp. 479-485.

In many cases there was insufficient sample volume (6 liters) for column concentration. In those instances, samples were composited from two different depths. For example, at Station 01, the 1-meter and the 15-meter samples were composited for the Cd, Zn, Cu, Mn, and Pb analysis. Samples not composited are indicated by only one depth.

QUALITY CONTROL DATA

The intralaboratory quality control data for mercury and lead indicate that the values obtained for the Deepwater Dumpsite seawater samples were real. However, the mercury and lead values were higher than that reported in the literature for these elements in seawater. To further validate the mercury values, four samples were sent to the EPA Southeast Water Laboratory at Athens, Ga. for mercury analysis by INAA (neutron activation analysis). Approximately 1-g samples of the four unknowns and standards were irradiated at 1 Mw, 1×10^{13} neutrons/cm²/sec for 6.4 hours in the Georgia Tech nuclear reactor. Two replicate standards and two replicate unknown samples were bundled together in alternate positions to minimize geometric variations in flux. Multichannel analysis was made about 30 days post irradiation for 60,000 seconds using a Ge (Li) detector with 11.5% efficiency, 37-1 peak-to-Compton ratio, and a 1.95 FWHM resolution with respect to the Co-60, 1332.5 gamma. The average value for the two standards was then computed with individual unknowns giving two values for each unknown. The following table presents this data and triplicate values obtained by atomic absorption spectrophotometry at this laboratory.

Sample	Neutron activation analysis (Hg $\mu\text{g/l}$)	Atomic absorption spectrometry (Hg $\mu\text{g/l}$)
060816	2.65, 2.57	1.20, 0.70, 0.55
031520	3.94, 3.41	2.40, 1.60, 1.40
031821	2.84, 3.09	2.70, 1.40, 1.40
020816	1.17, 1.39	1.40, 1.30, 0.65

Considering that two different laboratories and two different methods were used, the values show agreement even though neutron activation analysis values are generally higher.

In order to check for extraneous lead contamination during sampling, four samples taken from the vicinity of the hydrographic sampling apparatus on board the vessel Albatross IV were sent by the Northeast Fisheries Center, National Marine Fisheries Service, NOAA, Woods Hole, Mass., for Pb analysis. The samples (EPA Lab. Sample No.), their source and description, and results of analyses (Pb determined by atomic absorption spectrophotometry) follow:

Sample 41023: Five short lengths of 3/16-inch cable cut from the end of the warp on the starboard hydrographic winch on the upper deck. The strands of cable are heavily impregnated with grease which was extruded from cable in some quantity during the sample period. Water samples taken on the hydrographic casts could be contaminated with the grease. Result: 88 mg/kg/ Pb.

Sample 41024: A 10-inch length of rubber hose that was used to drain water from the 1.7 and 5 liter Niskin bottles used on the hydrographic casts and drained at the bottle rack on the main deck. The rubber hoses were stored in the trough beneath the rack and could have picked up contamination from the hose. Not analyzed.

Sample 41025: Sample of water taken from the drainage trough on the main deck where the hydrographic cast bottles were drained. At these racks, three troughs drain into one drain pipe. The sample was obtained by pouring ship tapwater into the three drains in about equal parts, collecting the water as it flowed from the drain pipe, then taking a plastic bottle of water from the mixed sample. Residues of paint were included in the sample. Result: 25 $\mu\text{g/l}$ Pb.

Sample 41050: Sample of water taken from the drainage trough on the upper deck where the 1.7 liter Niskin bottles from the STD were drained. This is a single trough and was sampled in a similar fashion to 41025 with tapwater from the ship's supply. Paint residues were also present in this sample. Result: 5 $\mu\text{g/l}$ Pb.

These analyses indicate potential sources of lead that may contaminate the seawater samples collected for analysis. It is extremely important that such sources be controlled in future cruises--especially when samples for lead are being collected.

Total coliform and fecal coliform densities were less than 1/100 ml at 15 of the 17 stations. Station Z and BB, however, did show low levels of coliform bacteria in the surface sample. It is our opinion that these organisms originated from the Albatross IV holding tank since this system has an automatic discharge that undoubtedly voided during the sampling program. In addition, floating garbage and other waste products were visible on the surface of the water. These materials originated from the vessel taking part in the sampling program.

Table 1.--Total coliform, fecal coliform, and heterotrophic marine bacteria in May 1974 samples from Deepwater Dumpsite 106 (expressed as bacteria per 100 ml)

Station	Date May 1974	Sample No. 1			Sample No. 2			Sample No. 3					
		Depth (m)	Total Coli- form	Fecal Coli- form	Marine Plate Count	Depth (m)	Total Coli- form	Fecal Coli- form	Marine Plate Count	Depth (m)	Total Coli- form	Fecal Coli- form	Marine Plate Count
V (5)	15	1	< 1	< 1	240	15	< 1	< 1	180	50	< 1	< 1	630
U (6)	16	10	*	*	2,000	150	< 1	< 1	1,120	400	< 1	< 1	40
T (7)	16	10	< 1	< 1	250	30	2	< 1	890	200	< 1	< 1	70
R (8)	17	5	< 1	< 1	240	30	< 1	< 1	240	200	< 1	< 1	340
Q (9)	17	5	< 1	< 1	100	30	< 1	< 1	40	200	< 1	< 1	290
P (10)	18	5	< 1	< 1	820	30	< 1	< 1	220	300	< 1	< 1	230
Z (11)	18	5	312	LA	1,080	30	< 1	LA	300	200	< 1	LA	730
L (14)	20	5	< 1	< 1	90	30	< 1	< 1	360	200	< 1	< 1	830
M (15)	20	5	< 1	< 1	60	30	< 1	< 1	100	200	*	*	20
N (16)	20-21	5	< 1	< 1	60	30	< 1	< 1	360	200	< 1	< 1	410
O (17)	21	1	< 1	< 1	390	15	< 1	< 1	30	148	*	*	*
BB (18)	21	5	23	4	600	30	< 1	< 1	70	200	< 1	< 1	160
AA (19)	22	5	< 1	< 1	80	30	< 1	< 1	240	200	< 1	< 1	150
X (20)	22	10	< 1	< 1	170	50	< 1	< 1	90	150	*	*	*
W (21)	22	5	1	< 1	30	25	< 1	< 1	70	125	< 1	< 1	420
FF (22)	23	5	< 1	< 1	330	30	< 1	< 1	200	300	< 1	< 1	140
EE (23)	23	5	< 1	< 1	100	30	< 1	< 1	120	300	< 1	< 1	210

1/ Albatross IV stations; letter and number designations.

* Insufficient sample volume

LA Laboratory accident.

Table 1.--Total coliform, fecal coliform, and heterotrophic marine bacteria in May 1974 samples from Deepwater Dumpsite 106 (expressed as bacteria per 100 ml)--continued

Station	Date May 1974	Sample No. 4				Sample No. 5			
		Depth (m)	Total Coli- form	Fecal Coli- form	Marine Plate Count	Depth (m)	Total Coli- form	Fecal Coli- form	Marine Plate Count
V (5)	15	100	< 1	< 1	1,270	110	< 1	< 1	760
U (6)	16	800	*	*	1,000	1,200	< 1	< 1	280
T (7)	16	700	< 1	< 1	180	1,700	*	*	*
R (8)	17	700	< 1	< 1	280	1,700	*	*	700
Q (9)	17	700	< 1	< 1	240	2,300	*	*	*
P (10)	18	1,200	< 1	*	120	2,560	< 1	< 1	50
Z (11)	18	700	*	*	900	2,180	< 1	LA	30
L (14)	20	1,200	< 1	< 1	120	2,330	< 1	< 1	320
M (15)	20	700	< 1	< 1	480	2,960	< 1	< 1	30
N (16)	20-21	1,200	< 1	< 1	40	2,800	< 1	< 1	170
O (17)	21	1,160	*	*	*	2,688	2	< 1	240
BB (18)	21	700	*	*	1,080	2,620	*	*	250
AA (19)	22	700	< 1	< 1	230	2,525	< 1	< 1	30
X (20)	22	300	< 1	< 1	770	500	< 1	< 1	320
FF (22)	23	800	< 1	< 1	160	1,275	< 1	< 1	100
EE (23)	23	800	< 1	< 1	LA	2,475	< 1	< 1	LA

I/ Albatross IV stations; letter and number designations

* Insufficient sample volume

LA Laboratory accident.

Table 2.--Total Kjeldahl nitrogen, nitrate-nitrogen, total phosphorus, and mercury in May 1974 samples from Deepwater Dumpsite 106.

Station No.	Bottle No.	Depth meters	TKN mg/l	NO ₃ -N mg/l	T-P mg/l	Hg µg/l
01	01	1	0.21	< 0.05	0.02	0.77
	02	15	0.23	< 0.05	0.03	0.80
	03	50	0.19	0.09	0.03	
	04	65	0.25	0.10	0.03	0.76
	05	75	0.28	0.10	0.03	0.86
02	01	1	0.11	< 0.05	< 0.01	0.76
	02	15	0.12	0.14	< 0.01	0.60
	03	50	0.14	0.70	0.03	0.67
	04	100	0.16	0.41	0.07	0.82
	05	300	0.06	0.31	0.05	0.63
	06	500	0.19	0.24	0.04	
	08	1,200	0.10	0.33	0.03	
	09	1,400	0.12	0.32	0.04	
	10	1,600	0.08	0.22	0.04	
04	02	1	0.12	< 0.05	0.03	0.86
	03	15	0.30	< 0.05	0.02	0.96
	04	50				
	05	300	0.17	0.30	0.06	1.03
	06	500				
	07	1,000	0.23	0.22	0.10	0.94
	08	1,100	0.19	0.21	0.05	0.87
	09	1,200	0.38	0.21	0.04	0.81
	10	1,230	0.19	0.21	0.04	0.73
05	01	1	0.08	0.05	0.02	0.96
	02	15	0.09	0.05	< 0.01	0.51
	03	50	0.05	0.06	0.01	0.43
	04	--				
	05	110	0.06	0.19	0.03	0.33
06	01	1	0.12	0.05	< 0.01	1.08
	02	290	< 0.05	0.22	0.06	0.28
	03	465	< 0.05	0.32	0.14	0.29
	04	753	0.12	0.27	0.06	
	05	984	0.05	0.23	0.03	0.34
	06	1,215	0.05	0.21	0.03	0.73
	07	1,313	< 0.05	0.23	0.03	0.32
	08	1,330	< 0.05	0.22	0.03	0.30
07	01	1	0.05	0.05	< 0.01	0.39
	02	15	0.05	0.06	0.02	0.79
	03	50	< 0.05	0.07	0.03	4.0
	05	300	< 0.05	0.29	0.06	0.48
	06	500	< 0.05	0.26	0.06	0.50
	08	1,500	< 0.05	0.22	0.04	
	09	2,000	< 0.05	0.21	0.03	3.1

Table 2 (continued)

Station No.	Bottle No.	Depth meters	TKN mg/l	NO ₃ -N mg/l	T-P mg/l	Hg µg/l
08	01	1	0.08	0.06	< 0.01	
	02	15	< 0.05	< 0.05	< 0.01	1.4
	03	50	0.06	0.06	0.02	0.63
	04	100	0.09	0.07	0.02	0.39
	05	300	< 0.05	0.26	0.04	
	06	500	0.13	0.25	0.04	0.70
	07	1,000	< 0.05	0.07	< 0.01	
	08	1,500	< 0.05	0.15	0.06	0.48
	09	2,000	< 0.05	0.15	0.08	0.43
	10	2,350	< 0.05	0.18	0.09	3.0
09	01	1	0.13	0.08	< 0.01	1.2
	02	15	< 0.05	0.06	0.01	0.30
	03	50	0.18	0.06	< 0.01	0.23
	04	100	< 0.05	0.11	< 0.01	
	05	300	0.15	0.31	0.06	0.47
	06	500	< 0.05	0.33	0.05	0.39
	07	1,000	< 0.05	0.25	0.03	
	08	1,500	0.16	0.22	0.08	
	09	2,000	< 0.05	0.27	0.03	0.30
	10	2,500	< 0.05	0.25	0.05	0.48
10	01	1	< 0.05	0.06	< 0.01	0.44
	02	15	< 0.05	0.06	< 0.01	0.19
	03	50	0.05	0.06	< 0.01	0.29
	04	100	< 0.05	0.08	< 0.01	1.1
	05					
	06	500	< 0.05	0.33	0.03	0.19
	07	1,000	< 0.05	0.37	0.06	0.44
	08	1,500	< 0.05	0.25	0.02	0.45
	09	2,000	< 0.05	0.25	0.04	
	10	2,600	< 0.05	0.27	0.07	0.27
11	01	1	0.05	0.08	< 0.01	0.67
	02	20	0.07	0.06	0.01	0.33
	03	57	< 0.05	0.08	< 0.01	0.91
	06	96	< 0.05	0.12	< 0.01	0.31
	07	597	< 0.05	0.15	0.01	0.23
	08	1,095	< 0.05	0.24	0.05	0.35
	09	1,600	0.10	0.25	0.01	0.71
	10	1,796	0.06	0.25	0.05	0.25
12	01	1	< 0.05	0.07	< 0.01	0.50
	02	15	0.05	0.08	0.02	0.99
	03	50	< 0.05	0.08	0.01	0.45
	04	100				0.29
	05	300	0.09	0.13	< 0.01	0.29
	06	500	< 0.05	0.36	0.05	0.20
	07	1,000	< 0.05	0.24	0.02	0.33
	08	1,500	< 0.05	0.24	0.04	0.61
	09	2,000	0.08	0.21	< 0.01	0.21
	10	2,400	0.06	0.23	0.04	0.58

Table 2 (continued)

Station No.	Bottle No.	Depth meters	TKN mg/l	NO ₃ -N mg/l	T-P mg/l	Hg µg/l
13	01	1	0.16	0.06	< 0.01	0.75
	02	5	0.06	0.07	0.01	0.25
	03	15	< 0.05	0.09	< 0.01	0.35
	04	34	0.10	0.09	0.01	
	05	97	< 0.05	0.17	0.01	
	06	297	< 0.05	0.33	0.06	0.25
	07	800	< 0.05	0.27	0.04	0.86
	08	1,300	< 0.05	0.25	0.01	0.46
	09	1,800	< 0.05	0.25	0.02	0.66
	10	2,200	0.05	0.34	0.11	
14	01	1	< 0.05	0.09	< 0.01	1.1
	02	15	0.08	0.05	< 0.01	0.53
	03	50	< 0.05	0.06	< 0.01	0.52
	04	100	< 0.05	0.06	0.03	0.52
	05	300	< 0.05	0.16	< 0.01	0.35
	06	500	< 0.05	0.32	0.03	0.57
	07	1,000	< 0.05	0.25	0.03	0.23
	08	1,500	< 0.05	0.24	0.02	
	09	2,000	< 0.05	0.21	0.01	0.75
	10	2,350	< 0.05	0.25	< 0.01	0.48
15	01	1	0.08	0.06	0.01	0.79
	02	15	0.15	0.06	< 0.01	1.7
	03	50		0.10	< 0.01	1.6
	04	100	< 0.05	0.19	0.02	1.2
	05	300	< 0.05	0.34	0.03	0.31
	07	1,000	< 0.05	0.16	0.02	0.77
	08	1,500	< 0.05	0.27	0.04	
	09	2,000	< 0.05	0.26	0.02	1.1
	10	2,700	< 0.05	0.24	< 0.01	0.80
16	01	1	< 0.05	0.07	< 0.01	0.87
	02	15	< 0.05	0.06	< 0.01	0.54
	03	50	0.10	0.08	< 0.01	0.27
	04	100				0.52
	05	300	0.09	0.38	0.08	0.24
	06	500	< 0.05	0.27	0.05	1.0
	07	1,000	< 0.05	0.23	0.01	
	08	1,500	< 0.05	0.27	0.03	0.92
	09	2,000	< 0.05	0.23	< 0.01	0.39
	10	2,820	< 0.05	0.20	0.05	0.52
17	02	10	0.08	0.05	0.04	0.58
	03	25	0.13	0.07	< 0.01	0.43
	04	50	0.08	0.05	< 0.01	1.5
	05	248	< 0.05	0.39	0.05	0.43
	06	449	0.12	0.25	0.06	0.35
	07	950	< 0.05	0.25	0.03	0.37
	08	1,449	< 0.05	0.23	0.06	0.33
	09	1,950	< 0.05	0.22	< 0.01	0.30
	10	2,770	0.07	0.24	0.01	0.58

Table 2 (continued)

Station No.	Bottle No.	Depth meters	TKN mg/l	NO ₃ -N mg/l	T-P mg/l	Hg µg/l
18	01	1	0.07	0.06	< 0.01	0.37
	02	15	< 0.05	0.07	< 0.01	1.8
	03	50	< 0.05	0.08	< 0.01	1.4
	04	100	< 0.05	0.15	0.01	0.23
	05	300	< 0.05	0.34	0.09	0.37
	06	500	< 0.05	0.24	0.05	0.34
	07	1,000	0.06	0.20	0.01	0.42
	08	2,000	< 0.05	0.23	0.03	0.37
	09	2,500	< 0.05	0.24	0.01	0.39
	10	2,650	< 0.05	0.22	0.06	0.37
19	01	1	< 0.05	0.07	0.01	0.79
	02	15	< 0.05	0.08	0.01	1.1
	03	50	< 0.05	0.07	< 0.01	0.47
	04	100	0.06	0.11	< 0.01	0.42
	05	300	< 0.05	0.29	0.06	0.36
	06	500	< 0.05	0.30	< 0.01	0.39
	07	1,000	< 0.05	0.22	0.02	0.32
	08	1,500	< 0.05	0.26	0.01	0.72
	09	2,000	0.07	0.22	0.02	1.2
	10	2,550	< 0.05	0.20	0.05	0.86
20	01	1	0.13	0.05	< 0.01	0.35
	02	15	< 0.05	0.09	< 0.01	0.11
	03	25	0.09	0.05	0.02	0.34
	04	75	0.07	0.09	< 0.01	0.30
	05	100	< 0.05	0.11	0.01	0.30
	06	200	< 0.05	0.13	< 0.01	0.47
	07	250	< 0.05	0.09	0.03	0.42
	08	350	< 0.05	0.20	0.02	0.18
	09	400	< 0.05	0.33	0.05	0.04
	10	650	< 0.05	0.25	0.06	0.04
21	01	1	0.07	0.06	0.01	0.72
	02	15	0.06	0.08	< 0.01	0.85
	03	50	0.19	0.07	0.01	0.31
	04	100	< 0.05	0.14	0.02	0.56
	05	130	< 0.05	0.23	0.02	0.96
22	01	1	0.10	0.05	< 0.01	0.29
	02	10	< 0.05	0.08	< 0.01	0.30
	03	50	0.06	0.05	< 0.01	0.43
	04	100	0.13	0.10	0.01	0.34
	05	200	< 0.05	0.12	0.02	0.64
	06	500	< 0.05	0.30	0.06	0.53
	07	700	< 0.05	0.28	0.06	0.47
	08	900	< 0.05	0.26	0.03	0.36
	09	1,000	< 0.05	0.24	0.04	0.62
	10	1,300	< 0.05	0.24	0.03	0.53
23	01	1	< 0.05	0.06	0.01	0.47
	02	15	0.09	0.05	0.02	0.53
	03	50	< 0.05	0.09	< 0.01	0.62
	04	100	< 0.05	0.10	< 0.01	0.33
	05	200	< 0.05	0.14	< 0.01	1.0
	06	500	0.09	0.17	0.04	0.36
	07	1,000	< 0.05	0.27	< 0.01	0.36
	08	1,500	< 0.05	0.26	0.03	0.53
	09	2,000	0.21	-0.27	0.03	0.53

Table 3.--Cadmium, zinc, copper, manganese, and lead in May 1974 samples from Deepwater Dumpsite 106

Station No.	Depth meters	Composite Depths meters	Cd $\mu\text{g/l}$	Zn $\mu\text{g/l}$	Cu $\mu\text{g/l}$	Mn $\mu\text{g/l}$	Pb $\mu\text{g/l}$
01		1 - 15	0.11	9.6	1.3	1.6	4.0
		65 - 75	0.08	6.4	1.0	1.6	4.0
02	1600	1 - 15	0.05	8.4	0.8	1.3	4.4
		50 - 100	0.09	12.0	0.8	1.2	4.4
		300 - 500	0.11	7.6	0.7	1.0	3.6
		1200 - 1400	0.08	4.4	0.7	1.0	4.0
			0.15	3.3	0.7	1.7	3.9
04		1 - 15	0.05	6.8	0.8	2.2	4.0
		300 - 500	0.07	4.8	1.0	1.2	4.4
		1000 - 1100	0.08	7.2	1.2	1.6	4.4
		1200 - 1230	0.08	6.6	1.0	1.2	4.4
05		1 - 15	0.24	5.2	0.4	1.3	2.6
		50 - 110	0.32	6.6	0.4	1.0	2.2
06	1330	1 - 290	0.24	6.2	0.4	0.9	2.2
		465 - 984	0.26	4.8	0.6	0.5	1.6
		1215 - 1313	0.40	7.0	1.6	0.7	1.6
			0.32	5.2	0.7	0.9	2.0
07	2000	1 - 15	0.60	21.4	1.7	1.4	2.8
		50 - 100	0.53	11.4	1.1	1.4	3.1
		300 - 1000	0.57	13.1	0.9	1.1	2.3
		500 - 1500	0.53	10.3	0.8	1.8	2.3
			0.59	10.6	0.7	1.0	3.9
08		1 - 15	0.30	7.8	0.8	1.7	3.9
		50 - 100	0.20	7.2	0.8	1.6	3.1
		300 - 500	0.22	7.1	0.6	1.3	2.3
		1000 - 1500	0.20	5.2	0.5	1.4	3.1
		2000 - 2350	0.21	9.2	0.4	1.3	3.5
09	2000	1 - 15	0.32	5.2	0.6	2.1	4.4
		50 - 100	0.32	2.4	0.3	1.5	3.4
		300 - 500	0.44	7.8	1.3	1.8	4.0
		1000 - 1500	0.56	3.6	0.6	2.4	6.1
			0.46	5.7	1.1	1.4	5.4
10	2600	1 - 15	0.45	6.7	0.7	1.4	3.1
		50 - 100	0.45	11.4	0.7	1.0	2.4
		500 - 1000	0.47	9.8	0.6	1.1	2.3
		1500 - 2000	0.51	4.3	0.5	0.6	1.6
			0.43	7.1	0.2	0.9	2.3

Table 3 (continued)

Station No.	Depth meters	Composite Depths meters	Cd $\mu\text{g/l}$	Zn $\mu\text{g/l}$	Cu $\mu\text{g/l}$	Mn $\mu\text{g/l}$	Pb $\mu\text{g/l}$
11		1 - 20	0.25	6.6	0.3	1.2	1.6
		57 - 96	0.44	4.4	0.6	1.3	1.5
		597 - 1095	0.28	5.4	< 0.2	0.5	1.6
		1600 - 1796	0.22	3.2	< 0.2	0.7	1.6
12		1 - 15	0.28	6.6	1.7	1.1	2.8
		50 - 100	0.44	6.4	1.1	1.1	2.6
		300 - 500	0.24	4.8	0.6	0.5	2.0
		1000 - 1500	0.22	4.8	0.4	1.0	1.6
		2000 - 2400	0.22	4.2	0.4	0.9	1.6
13		1 - 5	0.50	12.0	1.5	2.0	4.8
		15 - 34	0.44	8.8	1.2	1.8	4.0
		97 - 297	0.38	7.8	0.9	1.5	3.4
		800 - 1300	0.50	6.2	0.7	1.9	4.8
		1800 - 2200	0.28	8.4	0.5	4.5	2.2
14		1 - 15	0.16	4.0	0.4	1.0	2.0
		50 - 100	0.18	5.6	0.9	0.8	1.6
		300 - 500	0.18	4.4	0.4	0.8	1.6
		1000 - 1500	0.18	3.4	0.6	0.6	2.2
		2000 - 2350	0.24	5.0	0.6	0.6	0.8
15		1 - 15	0.13	6.2	0.7	1.9	2.4
		50 - 100	0.22	5.8	0.6	1.6	2.4
		300 - 500	0.20	5.6	1.5	1.7	3.9
		1000 - 1500	0.13	7.8	0.4	1.5	1.6
		2000 - 2700	0.24	4.5	0.7	2.2	4.0
16		1 - 15	0.42	7.4	0.6	2.4	4.6
		50 - 100	0.36	5.4	0.7	1.6	3.2
		300 - 500	0.44	5.6	0.6	2.2	5.6
		1000 - 1500	0.38	15.8	0.6	1.4	3.4
		2000 - 2820	0.22	4.6	0.6	0.8	2.6
17		10 - 25	0.20	9.0	0.6	2.3	3.9
		50 - 248	0.16	3.7	0.4	1.9	2.7
		449 - 950	0.14	6.6	0.4	1.5	2.0
		1449 - 1950	0.23	5.7	0.4	1.5	4.0
	2770		0.18	6.1	0.4	1.4	
18		1 - 15	0.33	2.8	0.4	1.1	2.7
		50 - 100	0.33	2.9	0.4	1.1	2.7
		300 - 500	0.45	3.6	0.4	0.8	3.1
		1000 - 2000	0.43	10.0	0.4	0.9	2.3
		2500 - 2650	0.41	3.3	0.4	1.2	2.8

Table 3 (continued)

Station No.	Depth meters	Composite Depths meters	Cd $\mu\text{g/l}$	Zn $\mu\text{g/l}$	Cu $\mu\text{g/l}$	Mn $\mu\text{g/l}$	Pb $\mu\text{g/l}$
19		1 - 15	0.15	9.1	0.6	1.6	2.9
		50 - 100	0.26	7.1	0.4	1.9	3.9
		300 - 500	0.20	7.2	0.3	1.6	3.6
		1000 - 1500	0.20	7.6	0.6	1.4	3.1
		2000 - 2550	0.22	7.6	0.3	1.4	2.3
20		1 - 15	0.34	8.2	0.4	1.2	3.2
		25 - 75	0.32	10.0	0.6	1.7	3.4
		100 - 200	0.44	7.0	0.4	1.0	3.2
		250 - 350	0.28	5.8	1.1	1.2	3.2
		400 - 650	0.26	13.4	0.4	1.0	2.6
21		1 - 15	0.38	4.4	0.6	2.1	4.6
		50 - 100	0.42	3.2	0.5	2.3	3.8
	130		0.41	1.6	0.7	1.9	3.3
22		1 - 10	0.36	5.2	0.6	2.4	4.0
		50 - 100	0.36	9.0	0.6	1.8	4.4
		200 - 500	0.38	9.2	0.6	1.7	4.0
		700 - 900	0.24	7.6	0.5	0.9	2.2
		1000 - 1300	0.38	4.8	0.6	2.0	4.6
23		1 - 15	0.40	5.4	0.6	1.3	2.8
		50 - 100	0.38	6.8	0.5	1.2	2.8
		200 - 500	0.36	5.2	0.5	1.3	2.8
		1000 - 1500	0.36	2.9	0.5	1.3	2.0
	2000		0.43	6.1	0.6	1.4	3.1

PRELIMINARY INVESTIGATION OF BENTHIC RESOURCES
AT DEEPWATER DUMPSITE 106

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INTRODUCTION

As noted by Sanders, Hessler, and Hampson (1963) the number of benthic samples collected from any particular area of the deep-sea environment is relatively small. Virtually nothing is known about the benthic populations in deep-sea environments presently used for disposal of waste materials. This paper reports the preliminary findings from a recent investigation of such a disposal area.

Deepwater Dumpsite 106, frequently called the chemical dumping ground, is located approximately 120 nautical miles southeast of New York Harbor, where the water depth exceeds 6,000 feet (1,829 m). As recently as 1968 the Corps of Engineers reported that only one firm, American Cyanamid, had used the area for disposal. Following the general format of an operations plan developed jointly by the National Oceanic and Atmospheric Administration (NOAA) and Environmental Protection Agency (EPA), a baseline benthic survey was conducted at Site 106 and at several stations in the surrounding area (fig. 1).

The principal objectives of the survey included: 1) the determination of the distribution, abundance, and diversity of the benthic infauna at Site 106 and in surrounding areas--in particular to relate our findings to those previously obtained by other investigators working in the Middle Atlantic Bight at similar water depths (Sanders, Hessler, and Hampson 1965; Wigley and McIntyre 1964); 2) the establishment of the variation in the infauna in samples collected at Site 106 and at stations surrounding 106 or in similar water depths; 3) the determination of the relationship between the benthic infauna and physical sediment types found at stations in different water depths; 4) the measurement of the quantities of heavy metals in sediments at Site 106 and other stations in similar depths; and 5) the measurement of the body burdens of heavy metals in organisms collected in the general vicinity of Site 106 and at other stations in similar water depths.

MATERIALS AND METHODS

At least two Smith-McIntyre quantitative bottom grab samples (area of surface sampled 0.1 m^2) were taken at each sampling station (fig. 1). Substantial amounts of surficial sediment were removed from the first of each pair of grab samples and analyzed for the presence of radioactive materials. Small aliquots of sediment were removed from each pair of samples and analyzed for heavy metal content and grain-size distribution. A small core aliquot also was removed for future study of the meiofauna.

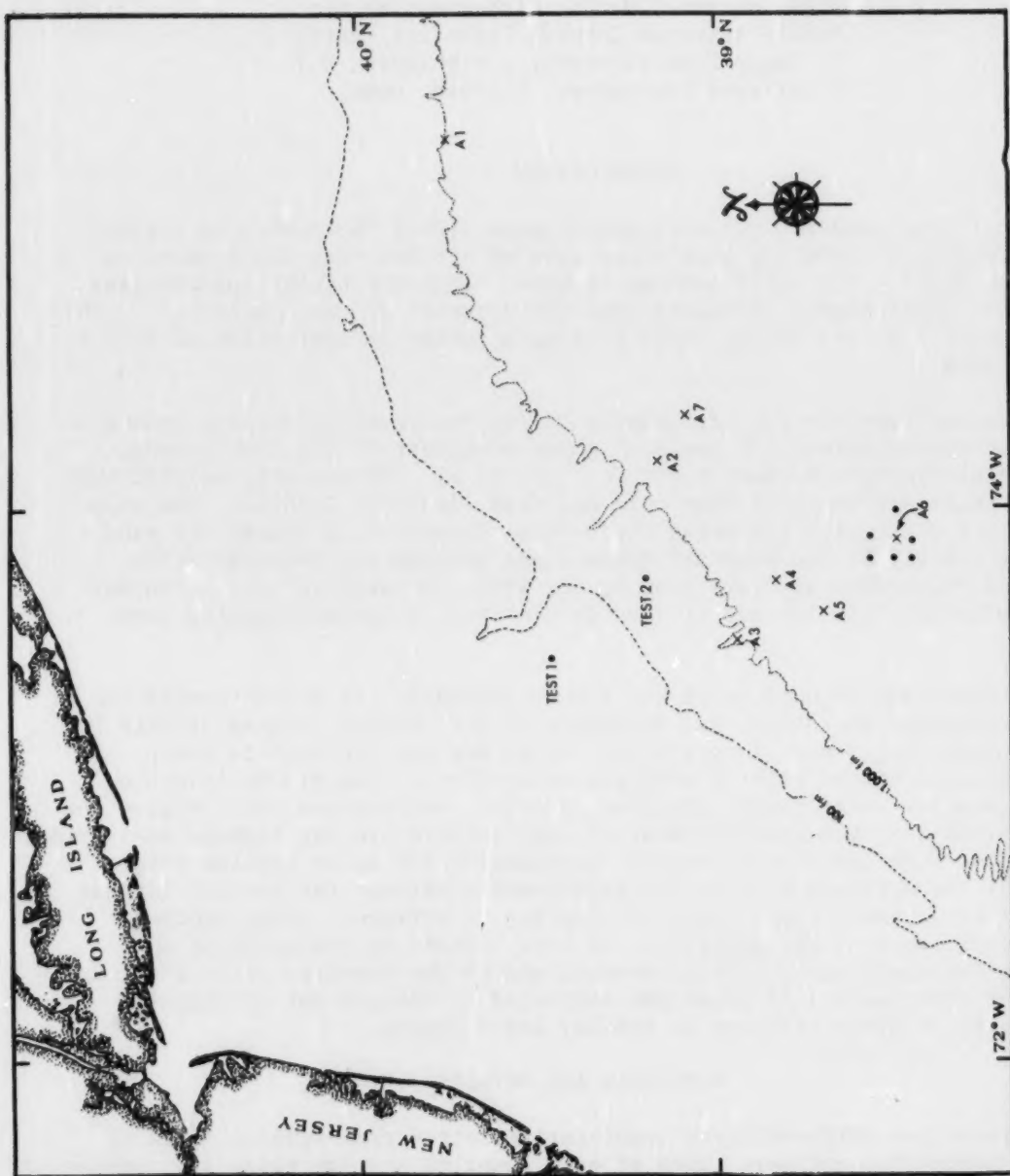


Figure 1.--Location of Smith-McIntyre bottom grab stations.

The sediments remaining in each grab sample were then washed through standard stainless steel screens with apertures of 1.00 and 0.50 mm. The materials remaining on the screens were fixed in formalin and preserved in 70% ethanol. Dissecting microscopes were used to pick biological materials from the preserved samples. Preliminary identifications were accomplished using the keys and descriptions developed by Hartman (1950, 1965), Pettibone (1957, 1963), Day (1967) and others.

Sediment samples were furnished to Anthony Cok (Department of Geology, Adelphi University) for standard geological analyses. These data are given in table 1. Sediments and tissues from epibenthic organisms were analyzed for their content of heavy metals by Richard Greig (Environmental Chemistry and Microbiology Investigation, NMFS, MACFC, Milford Laboratory) and reported in Graikoski et al. 1974. Their data are given in tables 2 and 3.

RESULTS

The number of individual organisms found in grab samples collected at each of seven sampling stations are quite similar, ranging from 19/0.1 m² at Station 2 to 48 at Station 7 (table 4). The number of taxa, based on very preliminary identifications, found at each station varied from 13 at Station 4 to 20 at Station 5 (table 4). Diversity (as H') varied from 2.035 at Station 4 to 2.756 at Station 5 (table 4).

These preliminary data are similar to the findings of other investigations of abyssal depths summarized by Sanders, Hessler, and Hampson (1965) in their section on faunal densities and composition. Polychaetes are the dominant taxon, followed by the pericardid crustaceans.

With one exception the metal contents of sediment samples collected in water deeper than 2000 m showed little variation from station to station (table 2). The station A1 sample contained less metal than the samples collected at stations A2 to A7.

Samples collected at Test Station 1 had considerably less metal (table 2). This station is located shoreward of the shelf-slope break; the heavy metal content of sediments is similar to values previously found in shelf sediments uncontaminated by domestic and industrial wastes (Pearce, 1972; Greig, 1974).

Sediments had relatively large amounts of sands, silts, and clays. Sediments from these depths were previously reported by Sanders, Hessler, and Hampson (1965) to consist principally of silts and clays with some sands (see their table 2).

The heavy metal content of tissues from several taxa of benthic invertebrates and demersal finfish is given in table 3. These data will be compared to recent data on heavy-metal burdens in the bodies of finfish trawled for on the continental shelf.

DISCUSSION AND SUMMARY

Further sampling and statistical analyses are required to determine the extent of variation in the infauna and sediment characteristics, including heavy metal contents, between stations. It is apparent, however, that the abundance of infauna at each station falls within the same order-of-magnitude as noted for abyssal sites by previous investigations. Diversity also is quite similar at all stations. At the present time there is no reason to assume that the toxic wastes disposed of at Site 106 have, in any way, impinged upon the sediments or fauna collected at the several benthic sampling stations in the vicinity of Site 106. The makeup of the benthic assemblages is very similar to what has been reported for deep-sea benthic faunal assemblages found at similar depths along the Gay Head to Bermuda transect (Sanders, Hessler, and Hampson, 1965).

The heavy metal content of the sediment samples appears elevated relative to uncontaminated continental shelf sediments. The fact that sediment samples collected at Station A1 were somewhat lower in heavy metal content than the other stations raises a number of questions. Generally it is assumed that silts and clays have more metals associated with them. Since Stations A2 to A7 are located near the Hudson Canyon outfall it might be possible that materials originating inshore, and having an elevated heavy metal content, are transported seaward via the shelf valley and canyon. Station A1 might be outside the influence of this "system."

Since there was relatively little variation in the heavy metal content of sediments at the sampled stations, it seems unlikely that the metal content in these sediments can be attributed to ocean disposal as presently practiced at Site 106.

In most of the finfish and invertebrates that were analyzed the levels of silver, cadmium, and chromium did not vary greatly. Copper, zinc, and lead did vary somewhat. Lead showed the greatest variation of the six metals (table 3).

Liver tissues from the deep-sea slickhead, Alepacephalus agassizi, had the highest levels of silver, cadmium, copper, and zinc. The values for these metals are several orders of magnitude greater than the metal concentrations found in windowpane flounder, Scophthalmus aquis, taken from the sewage sludge and dredge material disposal sites in the New York Bight apex (Greig, unpublished data). The levels of the metals in liver tissues from the slickhead were: cadmium, 13.9 ppm; copper, 28.6 ppm; silver, 1.2 ppm; and zinc, 271.0 ppm. All values are on a wet weight basis.

Additional liver tissue samples were removed from the deep-sea grenadier, Nematonurus armatus; rattail, Nezumia bairdi; whiting, Merloccius bilinearus; and Halosaupsis macrochin (no common name available). The levels of metals in these tissues were fairly similar to those found in livers of windowpane flounder taken in coastal waters.

Information presented by Windom et al. (1973) on cadmium, copper, and zinc values in 35 species of fish obtained from waters of the North Atlantic can be used for comparison with present data. They reported that cadmium

in liver tissue was generally less than 1.7 ppm, although one sample contained 5 ppm. Cadmium levels in other organs and whole fish usually were less than 1 ppm; however, some species had values as high as 2.6 ppm. Because the data by Windom et al. were expressed on a dry weight basis, their values (as reported herein) would have to be reduced to about one-fifth, assuming 80% moisture in fish tissues. The highest cadmium level of 5 ppm dry weight found by Windom et al., would be about 1 ppm on a wet weight basis. Copper levels were, in most cases, less than 10 ppm in fish tissues they sampled. The copper level in liver of deep-sea slickhead in our study was 28.6 ppm on a wet weight basis, which is more than triple the highest level of about 9 ppm on a wet weight basis, reported by Windom and coworkers. Copper concentrations in other species of fish obtained in the present study were similar to the levels in fish examined by Windom et al. (1973).

Zinc levels in North Atlantic fish were reported by Windom and coworkers to be in the range of 10 to 80 ppm on a dry weight basis. However, a high level of zinc at 397 ppm for the species Anchoa mitchilli was obtained. This level would be about 80 ppm on a net weight basis. Zinc levels found in most fish in our study were in this same range.

Because of the foregoing it is suggested that additional tissues should be taken from organisms collected at the Deepwater Dumpsite 106 and tested. Analyses of present samples indicated that at least some tissues from individuals of a particular species have a higher than usual body burden of metals. Scientists have long known that certain species of marine organisms selectively concentrate specific metals. It may be that the slickhead, for instance, is one such organism. In order to adequately assign baselines for body burdens of heavy metals in demersal and benthic organisms, additional specimens should be collected and analyzed for metals and other contaminants.

ACKNOWLEDGMENTS

Samples were collected during the period May 10-24, 1974, when the FRS Delaware II was involved in a joint NOAA-EPA operation at Deepwater Dumpsite 106. James Thomas, Ecosystems Investigations, NMFC, MACFC, was scientific party chief and responsible for field collections. Richard Greig, Ecosystems Investigations, conducted chemical analyses for heavy metal burdens in organisms and sediment. Ann Frame, David Radosh and Leslie Rogers (Ecosystems Investigations) sorted and tentatively identified benthic organisms. John Pearce, Director, Ecosystems Investigations, supervised the project and preparation of the data report.

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Table 1.--Sediment grain-size data

Station #	% Gravel	% Sand	% Silt	Mean ($\bar{x}$)	Median	Sorting (γ)	Skewness (Sk)	Kurtosis (K)
Test #2	-	10.875	89.124	6.79	6.42	2.538	.234	1.099
A1	-	26.069	74.774	6.2	5.75	3.103	.268	1.103
A2	1.0205	50.932	48.0466	4.67	3.93	3.147	.4082	.9826
A5	-	10.120	89.879	7.39	7.32	2.5808	-.009	1.125
SW of A6	-	10.875	89.124	7.566	7.58	2.45	-.040	1.108
A7	-	21.197	78.802	6.76	6.55	3.190	.1250	.8926

Table 2--Trace metal concentrations in the upper 1.5 inches of sediments
collected from stations near Deepwater Dumpsite 106

Station and grab number	Metal concentrations (ppm, dry sediment)				
	Cr	Cu	Ni	Pb	Zn
A1, grab 1	16.8	13.4	12.6	16.0	33.2
grab 2	21.8	21.6	20.6	24.0	45.0
A2, grab 1	26.2	28.2	24.2	26.0	60.0
grab 2	23.2	24.0	19.0	28.0	53.0
A3, grab 1	25.6	28.0	22.8	26.0	59.0
grab 2	23.4	19.6	17.8	24.0	58.0
A4, grab 1	27.4	29.6	28.4	32.0	63.0
grab 2	24.2	26.6	24.4	32.0	56.0
A5, grab 1	26.8	31.2	29.6	32.0	61.0
grab 2	28.0	30.6	28.4	26.0	64.0
A6, grab 1	28.6	37.2	32.4	26.0	65.0
grab 2	27.8	34.8	31.8	30.0	53.0
A4, grab 1	25.4	26.2	23.0	26.0	56.0
grab 2	22.6	23.6	22.4	20.0	53.0
A6, N	26.8	32.0	28.6	26.0	56.0
E	24.6	36.0	28.2	26.0	56.0
S	23.4	29.0	29.8	24.0	52.0
SW	26.4	32.6	26.4	28.0	54.0
W	27.4	34.0	27.8	30.0	57.0
NW	26.6	34.6	33.6	28.0	58.0
Test 1, grab 1	6.8	3.0	3.2	6.0	14.8
grab 2	6.6	3.0	4.2	8.0	13.2

Table 3.--Trace metal concentrations in marine biota collected offshore in the New York Bight

Common name Scientific name	N*	Tissue	Latitude	Longitude	Ag	Metal concentrations (ppm, wet wt.)				
						Cd	Cr	Cu	Pb	Zn
Butterfish	5	whole	39 30	72 34	0.14	0.23	0.54	4.6	1.1	28.8
<u>Prepilus triacanthus</u>										
<u>Deep-sea slickhead</u>	3	muscle	38 50	72 34.5	< 0.09	0.09	< 0.3	0.2	< 0.3	11.6
<u>Alephacephalus agassizi</u>										
<u>Deep-sea slickhead</u>	11	liver	38 50	72 34.5	1.16	13.9	0.6	28.6	0.5	271.0
<u>Alephacephalus agassizi</u>										
<u>Deep-sea slickhead</u>	11	gills	38 50	72 34.5	0.12	0.27	0.5	1.1	1.3	69.0
<u>Alephacephalus agassizi</u>										
<u>Deep-sea grenadier</u>	3	muscle	30 09	72 19.5	< 0.08	< 0.07	0.4	0.4	< 0.4	3.7
<u>Nematonurus armatus</u>										
<u>Deep-sea grenadier</u>	9	liver	39 09	72 19.5	< 0.1	< 0.1	1.1	2.4	< 0.6	18.5
<u>Nematonurus armatus</u>										
<u>Deep-sea grenadier</u>	9	gills	39 09	72 19.5	0.15	0.08	0.8	1.2	2.0	18.0
<u>Nematonurus armatus</u>										
<u>Deep-sea grenadier</u>	11	whole	39 02	72 25	0.20	0.17	0.94	2.2	2.1	12.3
<u>Nematonurus armatus</u>										
--										
<u>Dicrolene intronigra</u>										
<u>Eel</u>	11	whole	39 02	72 25	0.11	0.51	0.58	4.2	1.7	14.7
<u>Synaphobranchus kaupi</u>										
--	4	muscle	38 38	72 06	< 0.09	< 0.07	< 0.45	2.7	< 0.4	4.3
<u>Halosaupsis macrochin</u>										
--	3	liver	38 38	72 06	0.33	0.30	< 0.67	2.0	< 0.6	4.9
<u>Halosaupsis macrochin</u>										
--	3	gills	38 38	72 06	0.16	0.13	0.75	1.4	2.3	15.5
<u>Halosaupsis macrochin</u>										
--	2	gonad	38 38	72 06	< 0.29	< 0.23	1.4	3.6	< 1.2	55.5
<u>Halosaupsis macrochin</u>										
--	3	muscle	39 30	72 34	0.09	< 0.07	< 0.40	1.2	0.8	9.7
<u>Nematonurus armatus</u>										
--	3	gills	39 30	72 34	< 0.10	0.08	0.58	1.4	1.3	27.0
<u>Nematonurus armatus</u>										
--	18	whole	38 38	72 06	0.54	0.83	1.00	4.0	8.0	59.4
<u>Pontaster hebitus</u>										

Table 3.--Trace metal concentrations in marine biota collected offshore in the New York Bight (continued)

Common name Scientific name	N*	Tissue	Latitude	Longitude	Metal concentrations (ppm, wet wt.)					
					Ag	Cd	Cr	Cu	Pb	Zn
			°N	°W						
Rattail	60	whole	39 09	72 19.5	0.17	0.26	0.95	3.0	2.7	32.9
Nezumia bairdi										
Rattail	4	muscle	39 02	72 25	< 0.08	< 0.07	0.45	0.6	0.6	5.8
Nezumia bairdi										
Rattail	4	liver	39 02	72 25	0.12	0.79	< 0.5	10.9	0.8	59.9
Nezumia bairdi										
Rattail	7	gills	39 02	72 25	0.21	0.15	< 0.7	2.2	4.2	32.0
Nezumia bairdi										
Rattail	11	gonad	39 02	72 25	< 0.08	0.15	< 0.4	6.5	1.1	56.0
Nezumia bairdi										
Redcrab	1	muscle	39 09	72 19.5	0.16	0.11	0.48	25.2	0.6	51.0
--										
Redcrab	1	digestive gland	39 09	72 19.5	0.62	1.14	< 0.42	107.0	1.2	19.6
--										
Sea cucumber	1	whole	38 50	72 34.5	0.48	0.03	0.23	0.2	0.3	1.3
Benthedites giganticus										
Whiting	4	muscle	39 30	72 34	< 0.09	< 0.08	0.49	1.0	< 0.3	4.2
Merloccius bilineatus										
Whiting	4	gills	39 30	72 34	< 0.09	0.15	0.54	1.8	2.4	26.8
Merloccius bilineatus										
Whiting	4	liver	39 30	72 34	0.08	0.29	0.52	14.7	< 0.4	12.2
Merloccius bilineatus										
Whiting	4	gonad	39 30	72 34	< 0.09	0.07	0.45	1.2	< 0.4	12.7
Merloccius bilineatus										
Witch flounder	58	whole	39 09	72 19.5	0.13	0.20	0.73	1.8	3.3	14.7
Glyptocephalus cynoglossus										

*N = Number of samples.

Table 4.--Benthic fauna at Deepwater Dumpsite 106 stations

Species	Number of individuals/0.1 m ² at stations						
	#1	#2	#3	#4	#5	#6	#7
Actiniaria		1					
Rhyncocoela			2	1	2		1
Nematoda	4	4	5	16	9	2	19
Oligochaeta	2	2		2	1	1	3
Polychaeta:							
Glycera capitata	3		2	1	2		3
Ampictes gunneri						1	
Leanira minor		1					
Syllis cornuta			1			3	
Ancistrosyllis groenlandica						1	
Neopodarke woodsholea			1				
Nereis #1		1					
Mediomastus ambiseta							1
Notomastus latericuis	1		1	4	3	1	
Heteromastus #1		1					
Praxillella gracilis		1					1
Maldanidae #1			1	1	1		
Ammotrypane abranchiata							1
Ammotrypane #1					1		
Nicomache lumbricalis	1						
Prionospio steenstrupi		1					
Spionides #1		1					
Spiophanes #1	1						1
Spiophanes #2					1		2
Paraonis abranchiata					1		
Paraonis sensustricta						1	
Paraonis gracilis		1		1	1		2
Paraonis cornatus					1	1	1
Aricidia tetrabanchia	1		3				
Travisia gravieri			1		1		
Lumbrineris latreille					2	1	
Lumbrineris tenuis		1					
Poecilochaetus fulgoris			8				7
Orbiniidae #1						1	
Paramphinome jeffreysii	1				1		
Tharyx acutus						1	
Tharyx annulosus	1						
Tharyx #1	2	2	2	7	4	1	1
Ampharete #1							1
Terebellidae #1				1			
Terebellides lobatus			1				
Sabellides #1			1				
Sipunculida #1		1					
Bivalvia:							
Nucula proxima	2		2				
Bivalve #1			1				

Table 4.--Benthic fauna at Deepwater Dumpsite 106 stations (continued)

Species	Number of individuals/0.1 m ² at stations						
	#1	#2	#3	#4	#5	#6	#7
Copepoda	x	x		x	x	x	x
Peracarida:							
Cumacea #1	1						
Cumacea #2					1		
Isopoda #1			1				
Tanaidacea #1						1	
Ampelisca agassizi	3						
Harpinia neglecta		1	1	3	2		
Harpinia abyssi				1			
Euphavsicea #1				3	1	1	
Decapoda #1				1			
Lucifer Faxoni						1	
Crustacea #1						1	
Amphipholis squamata	1				3		1
Unidentified vermiform #1			1		3	2	3
Chaetognatha				1	2	1	1
Total number of individuals	24	19	34	42	41	21	48
Total number of taxa	14	14	18	13	20	17	16
Diversity (H')	2,499	2,507	2,596	2,035	2,720	2,756	2,158

The data presented in this report are tentative. Before referencing the report, permission should be obtained from the Director, Middle Atlantic Coastal Fisheries Center.

ARCHIBENTHIC AND ABYSSOBENTHIC FISHES OF DEEPWATER DUMPSITE 106
AND THE ADJACENT AREA¹

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Section I: Community structure and ecology of demersal fish at
Deepwater Dumpsite 106

J. A. Musick

INTRODUCTION

Deepwater Dumpsite 106 (DWD 106) is located 145 km off the coast of New Jersey and is bounded by the latitudes of 38°40' and 39°00'N and longitudes 72°00' and 72°30'W. The depth of DWD 106 varies from about 1300 m in the northwest corner to 2700 m in the southeast (fig. 1). Most of the site is deeper than 2000 m. Within DWD 106 is a smaller dumpsite that has been in use for many years for industrial wastes and munitions. Due south of DWD 106 is an additional dumpsite (fig. 1) at which the Atomic Energy Commission reported dumping radioactive wastes (rad site). The purpose of this report is to describe the fish fauna in the area of DWD 106 and to provide information on the ecology of dominant species.

Studies of the demersal fishes on the continental slope and rise off the Middle Atlantic States began in the latter half of the nineteenth century with the cruises of the Blake and Albatross (Agassiz, 1888) that culminated in the publication of Goode & Bean's classic "Oceanic Ichthyology" (1896). These early reports were little more than lists of species (many of which were new to science). Virtually no research was done on demersal slope fishes in this region again until a half century later when Schroeder (1955) reported geographic and depth distribution of several species trawled between Nova Scotia and Virginia--as deep as 1335 m. Edwards, Livingston, and Hamer (1962) noted the results of a series of trawl transects to depths of about 400 m between Cape Hatteras and Nantucket Shoals. Haedrich and Horn (1970) recorded the catch from one trawl station at 1280 m in Hudson Canyon and Haedrich and Polloni (1974) compared that catch to another from a single trawl taken 4 years later at the same place. Markle and Musick (1974) studied demersal fish species associations and diversity in a series of 11 otter trawl catches made at about 900 m between Cape Hatteras and Block Canyon.

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2 Principal investigator. Section II is based in part on a dissertation in progress by C. A. Wenner and Section III on a thesis in progress by G. R. Sedberry; any reference made to information therein is restricted to the data collected at Deepwater Dumpsite 106.

3 V.I.M.S. contribution number 722.

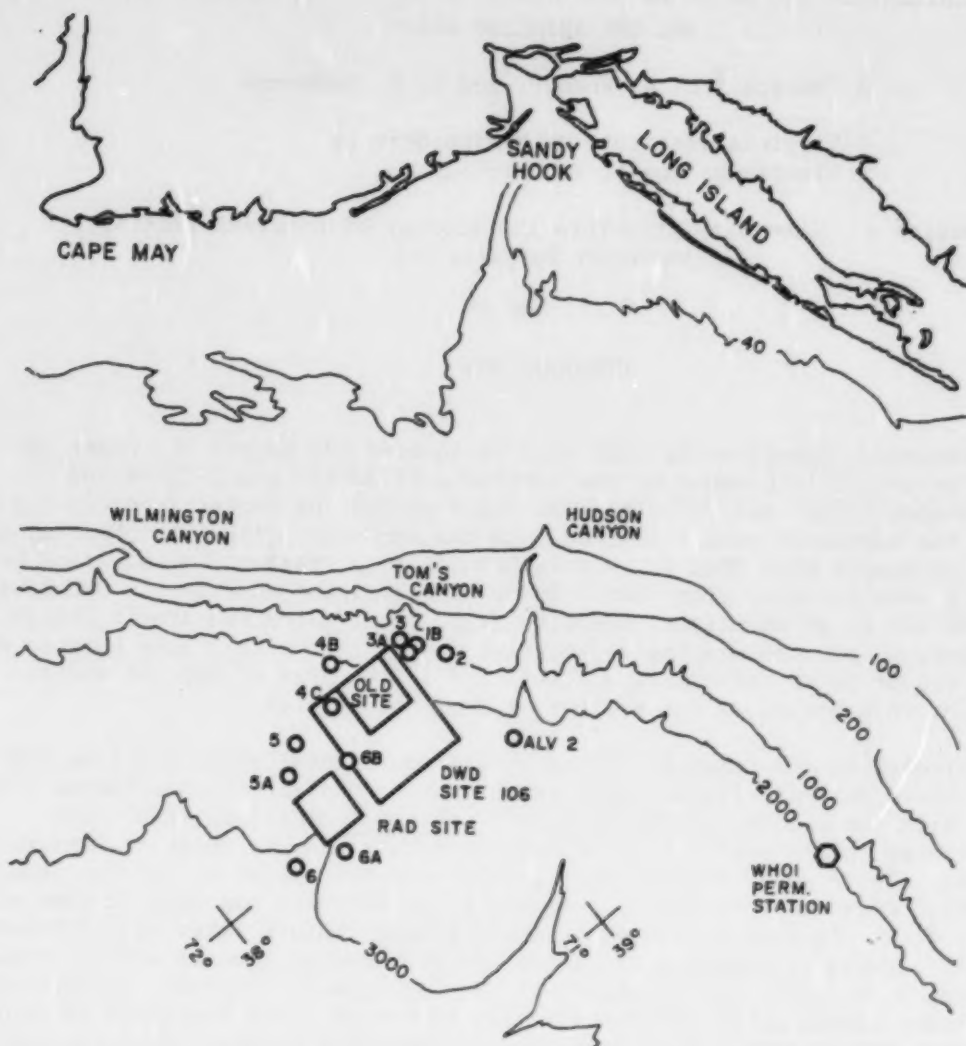


Figure 1.--Deepwater Dumpsite 106 and adjacent area including bottom trawl station locations for NOAA ship Delaware II cruise 74-2.

METHODS OF DATA COLLECTION

Delaware II Data. A trawl reconnaissance was made in and around DWD 106 from Delaware II on cruise D-2-74 from May 14 to 17, 1974, inclusive. Fourteen successful tows, each of 1 hour duration, were made at depths of 951 to 2820 m using a 45-foot (13.7-m) semiballoon otter trawl. Trawl characteristics include: 2-inch (4.45-cm) stretch mesh in wings and body,

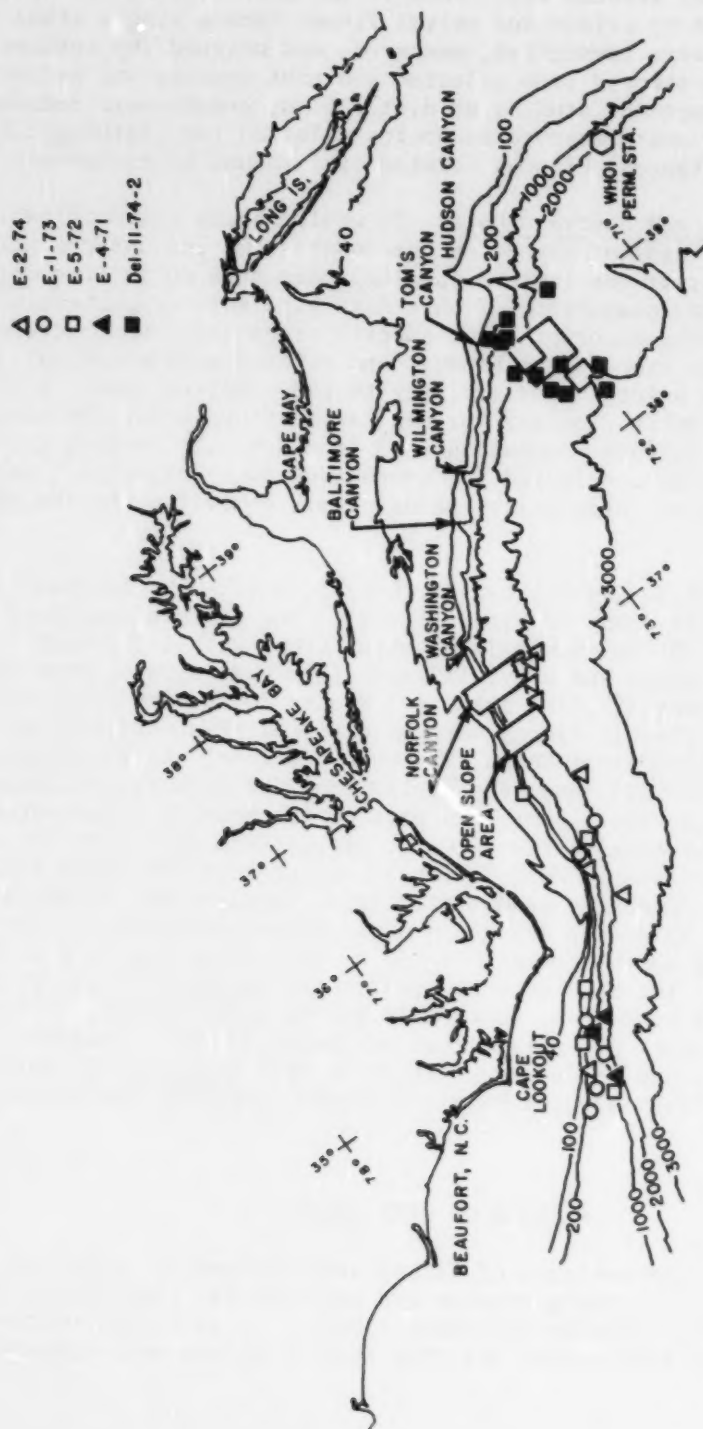


Figure 2.--Trawl stations on the continental slope and rise made on RV Eastward cruises E-4-71, E-5-72, E-1-73, E-2-74, and Delaware II cruise 74-2. The locations of RV C. O. Iselin Norfolk Canyon and open slope study areas are also shown.

1/2-inch (1.27-cm) stretch mesh liner in the codend, China "V" otter doors, and 90-foot (27.4-m) bridle and swivel fished from a single trawl warp. All fishes captured were identified, measured, and weighed (by species). Digestive tracts were removed from selected dominant species and preserved in 10% formalin for subsequent studies of diet. Also, gonads were removed from selected species and preserved in Bouins solution for histological preparation and, in some instances, Gilsons solution for fecundity estimates.

C. O. Iselin and Eastward Data. It would not be scientifically prudent to define assemblages of fishes on the lower slope and upper continental rise on the basis of the limited sampling permitted during the Delaware II program. However, comparison of this data with more comprehensive data allows a reasonable description of species assemblages and patterns of diversity and distribution of biomass and related parameters, at least as reflected in the animals' availability to the sampling gear. Data for comparison are available from our Norfolk Canyon Slope Study (sponsored in part by the National Science Foundation) and from several training cruises on the RV Eastward. We have selected for comparison data collected primarily in April, May, or June (seasonally approximately equivalent to the Delaware II data).

Eastward cruises E-4-71, E-5-72, E-1-73, and E-2-74 included 32 stations on the continental slope or rise (fig. 2). The net used on these cruises was the 30-foot (9.1-m) semiballoon otter trawl with 1-1/2-inch (3.81-cm) stretch mesh in wings and body, 1/2-inch (1.27-cm) stretch mesh liner in codend, and 90-foot (27.4-m) bridles. Wooden doors with steel double strap-shoes and solid plastic floats were used for all Eastward cruises except in 1974, at which time steel China "V" doors and four 2-liter gasoline-filled floats were used. All tows were of 1/2 hour duration except those deeper than 2000 m which were 1 hour. As part of the Norfolk Canyon study, a spring cruise was made on the RV C. O. Iselin from June 1 to 20, 1973, and work was concentrated in Norfolk Canyon and an adjacent "open slope" study area (fig. 3). Intensive random stratified sampling was conducted from 75 to 2000 m (fig. 3) with 3 day and 3 night trawls randomly allocated to each of the following depth strata: 75-150 m, 150-400 m, 400-1000 m, 1000-2000 m. Fishing gear was the same as that used in the Delaware II study, but tow duration was 1/2 hour. All catch data in the analyses that followed were converted to a catch per-unit effort of one-half hour. However, table 1 gives actual catches of demersal fishes at each Delaware II station. The term "demersal fish" as used herein includes so-called benthopelagic fishes (Marshall 1967).

METHODS OF DATA ANALYSIS

Clustering. Assemblages of fishes were defined by computing a distance coefficient, $D(j,k)$, among species and subsequently classifying species into clusters or groups (Sneath and Sokal, 1973). In addition, stations were clustered in the same manner and then species groups were compared to station (site) groups.

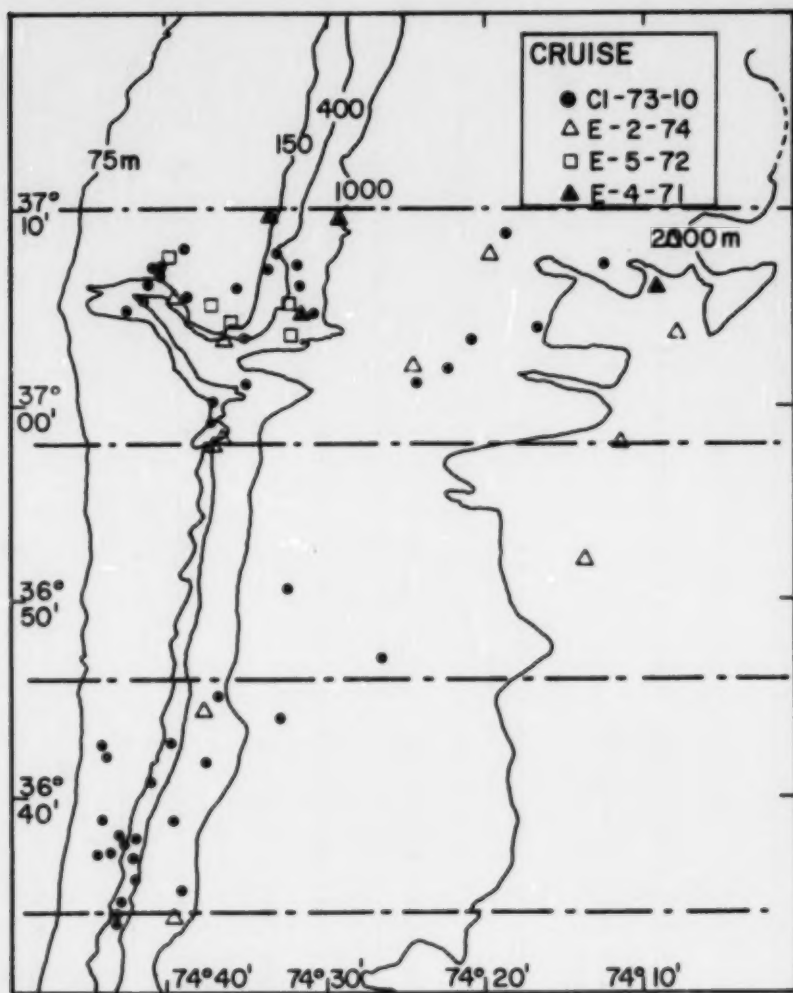


Figure 3.--Norfolk Canyon, adjacent continental slope, and locations of stations on RV C. O. Iselin cruise CI-73-10 and RV Eastward cruises E-4-71, E-5-72, and E-2-74. Stations between canyon and slope areas were considered to be part of the open slope.

Table 1.--Demersal fishes captured at DWD-106 trawl stations

Station #	2	3	3B	3A	4B	ALV2	4C	5	6B	6A	5A	6
Depth (m)	951	1143	1207	1353	2130	2286	2377	2620	2700	2745	2745	2745
Taxon												
Chimaeridea												
Hydrolagus affinis						1						
Rhinochimaeridae												
Harriotta raleighana	2		6				1					
Squalidae												
Centroscyllium fabricii			2									
Centroscymnus coelolepis	1											
Rajidae												
Raja bathyphila		1		2								
Raja jenseni												
Bathyraja richardsoni												
Synaphobranchidae												
Synaphobranchus kaupii	321	20	40	12	5							
Ilyophis brunneus		3										
Nettastomatidae												
Venefica procera		1										
Simenchelyidae												
Simenchelys parasiticus												
Halosauridae												
Halosaurus guentheri		2										
Halosaurus macrochir												
Aldrovandia affinis			3									
Aldrovandia phalacra	3	35	3									
Aldrovandia rostrata			5									
Notacanthidae												
Polyacanthonotus africanus												
Notacanthus chemnitzii												
Alepocephalidae												
Alepocephalus agassizii	4	12	29	1	1							
Grimatocrotes bullisii												
Narctes stomias												

Table 1 (continued)

Station #	2	3	3B	3A	4B	ALV2	4C	5	6B	6A	5A	6
Depth (m)	951	1143	1207	1353	2130	2286	2377	2620	2700	2745	2745	2745
Taxon												
Synodontidae												
Bathysaurus agassizii					2							1
Bathypteroidae												
Benthosaurus grillator												2
Ogocephalidae												
Dibranchius atlanticus												1
Chaunacidae												
Chaunax sp.												1
Gadidae												
Urophycis tenuis												2
Phycis chesteri												4
Ophidiidae												
Dicrolene intronigra												16
Monomitopus agassizii												1
Xyelacyba myersi												1
Porogadus miles												8
Macrouridae												
Nezumia bairdii												6
Nezumia aequalis												2
Nezumia cyrano												1
Coryphaenoides rupestris												13
Coryphaenoides armatus												8
Coryphaenoides leptolepis												4
Coryphaenoides carpinus												31
Moridae												
Antimora rostrata												15
Halargyreus johnsonii												1
Lotella sp. A												1
Zoarcidae												
Lycodes atlanticus												5
Lycenchelys paxillus												22
Lycodon mirabilis												1

Table 1 (continued)

Station #	2	3	3B	3A	4B	ALV2	4C	5	6B	6A	5A	6
Depth (m)	951	1143	1207	1353	2130	2286	2377	2620	2700	2745	2745	2745
Taxon												
Stephanoberycidae												
Acanthochaenus lütkeni												
Cottidae												
Cottonculus thompsoni												
Cyclopteridae												
Paraliparis garmani												
Pleuronectidae												
Glyptocephalus												
cynoglossus												

The distance coefficient chosen was the Canberra metric, which is particularly of value when the organisms under study are contagiously distributed (W. Stephenson, personal communication) as are most fishes. Also to further reduce the effects of occasional large catches, the transformation, $\log_e (X+1)=y$ was applied to numerical abundance data before analysis (Taylor 1953). The Canberra metric coefficient was defined by Lance and Williams (1967) as:

$$D(j,k) = \frac{\sum_{i=1}^n |X_{ij} - X_{ik}|}{\sum_{i=1}^n (X_{ij} + X_{ik})}$$

where in species analysis (inverse analysis) X = the number of species j and k at station i , and in station analysis (normal analysis) X = the number of species i at stations j and k .

The Canberra metric is a dissimilarity function, but in practice the complement is used to yield a similarity function before clustering (Williams, 1971). The clustering strategy used herein is flexible with $\beta = -0.25$ (Lance and Williams, 1967b), and is an agglomerative hierarchical procedure which avoids chaining and is space conserving (Sneath and Sokol, 1973).

RESULTS

Cluster analysis--site clusters. Examination of the dendrogram (figs. 4 and 5) depicting the results of the site group cluster analyses shows four major site groups, A-D. Group B includes Iselin stations made at 37 to 136 m, C includes stations from 403 to 986 m, and D, stations from 166 to 390 m. Group A is the most relevant to the present report because within it are included all of the Delaware II stations as well as Iselin stations with high similarity to the DWD 106-stations. Site group A may be further divided into three sub-groups A¹, A², A³.

Cluster analysis--species clusters. Six species groups, A-F, are evident in figures 6, 7, and 8. Of these, D-F include species assemblages from the upper slope and outer continental shelf, and occur well above the bathymetric limits of DWD 106. Species groups A, B, and C occur within the bathymetric limits of DWD 106.

Percent dominance. The five most dominant fishes at each of the DWD-106 stations are ranked by numerical abundance in table 2 and by biomass (wet weight) in table 3. Stations are arranged according to depth.

The five most dominant species at CI-74-10 stations deeper than 900 m are similarly listed in table 4. Those from Eastward stations deeper than 900 m and north of Cape Hatteras are included in table 5.

Depth ranges of dominant species. When sufficient data were available, log-transformed abundance of selected dominant species were plotted against depth and modal depths were computed using a computer algorithm developed by Gauch and Chase (1974). Both DWD-106 and Iselin data were included.

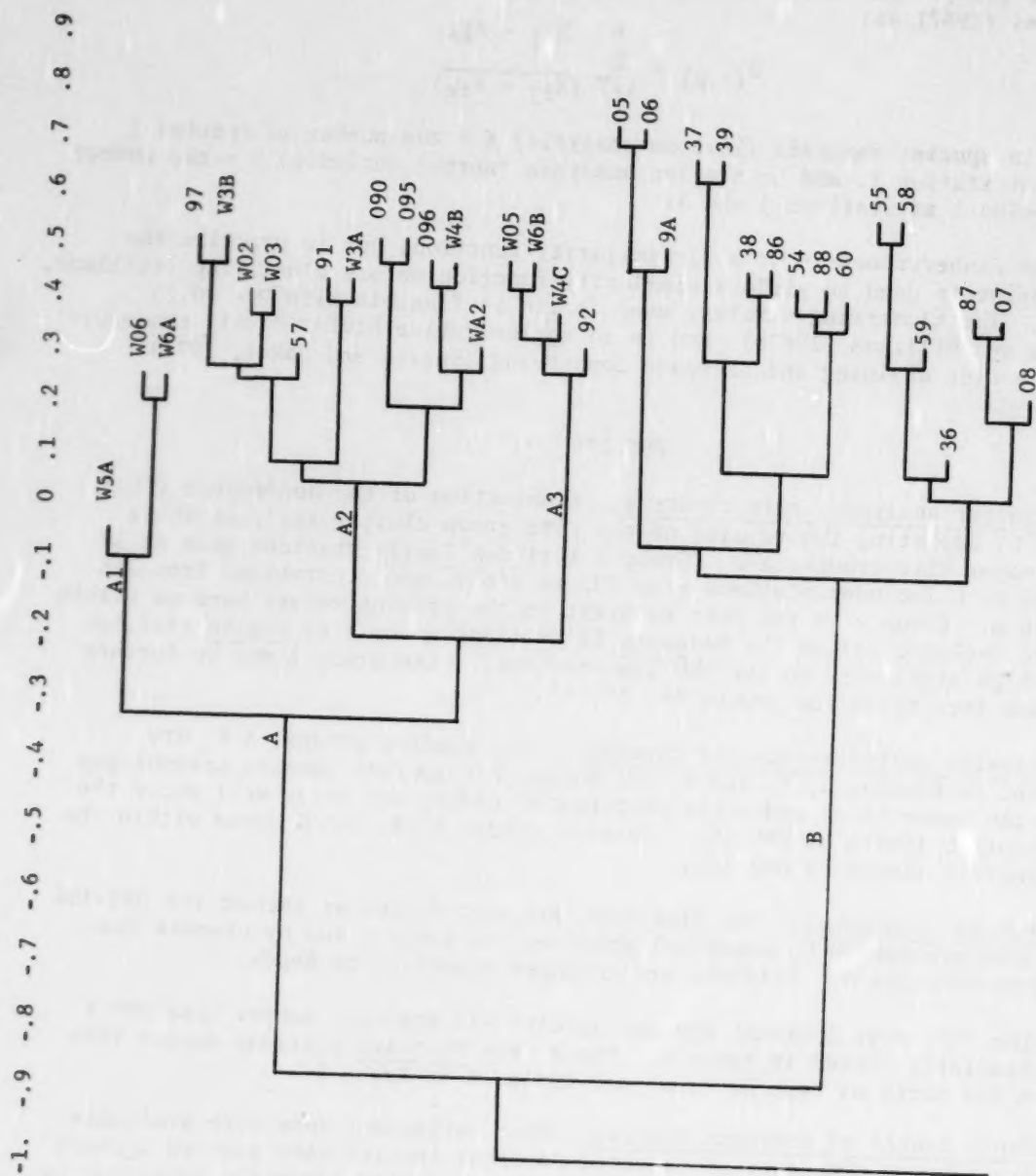


Figure 4.--Upper section of dendrogram depicting site group clusters. DWD stations are noted with the prefix "w". All other stations are from RV C. O. Iselin cruise 73-10.

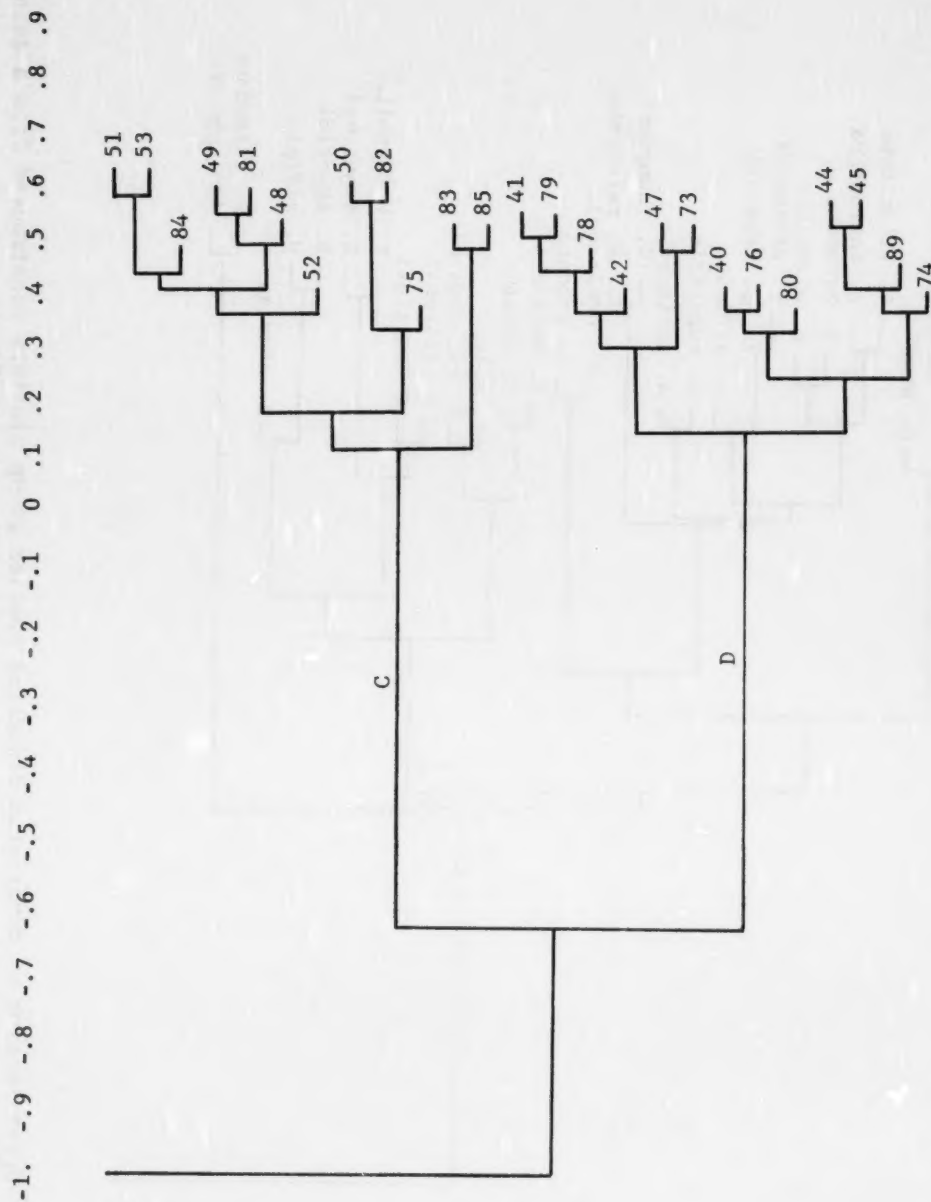


Figure 5.--Lower section of dendrogram depicting site group clusters. DWD stations are noted with the prefix "W". All other stations are from RV C. O. Iselin cruise 73-10.

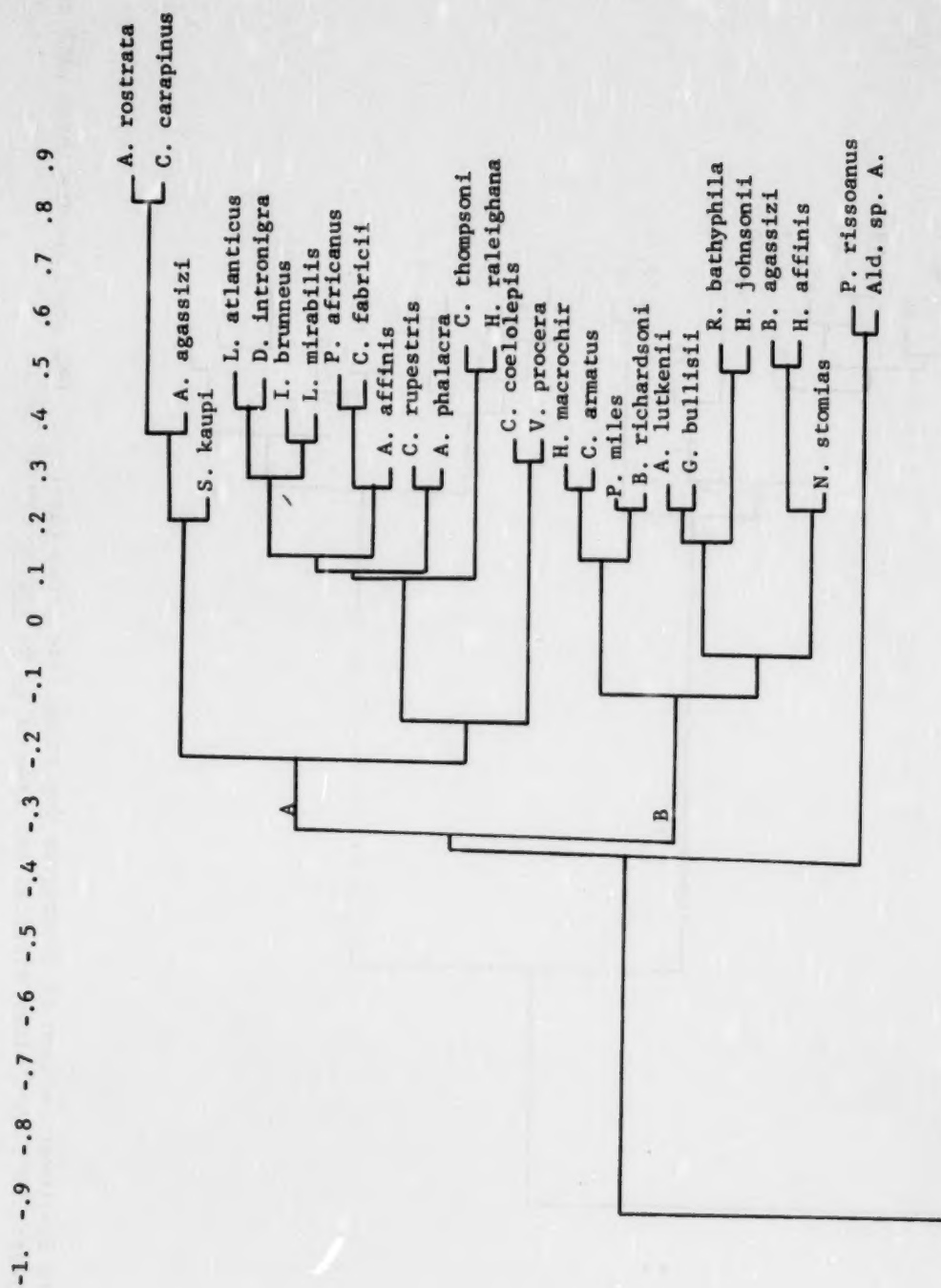


Figure 6.--Upper section of dendrogram depicting species group clusters constructed from a data matrix including trawl catches from DWD 106 and RV C. O. Iselin cruise 73-10.

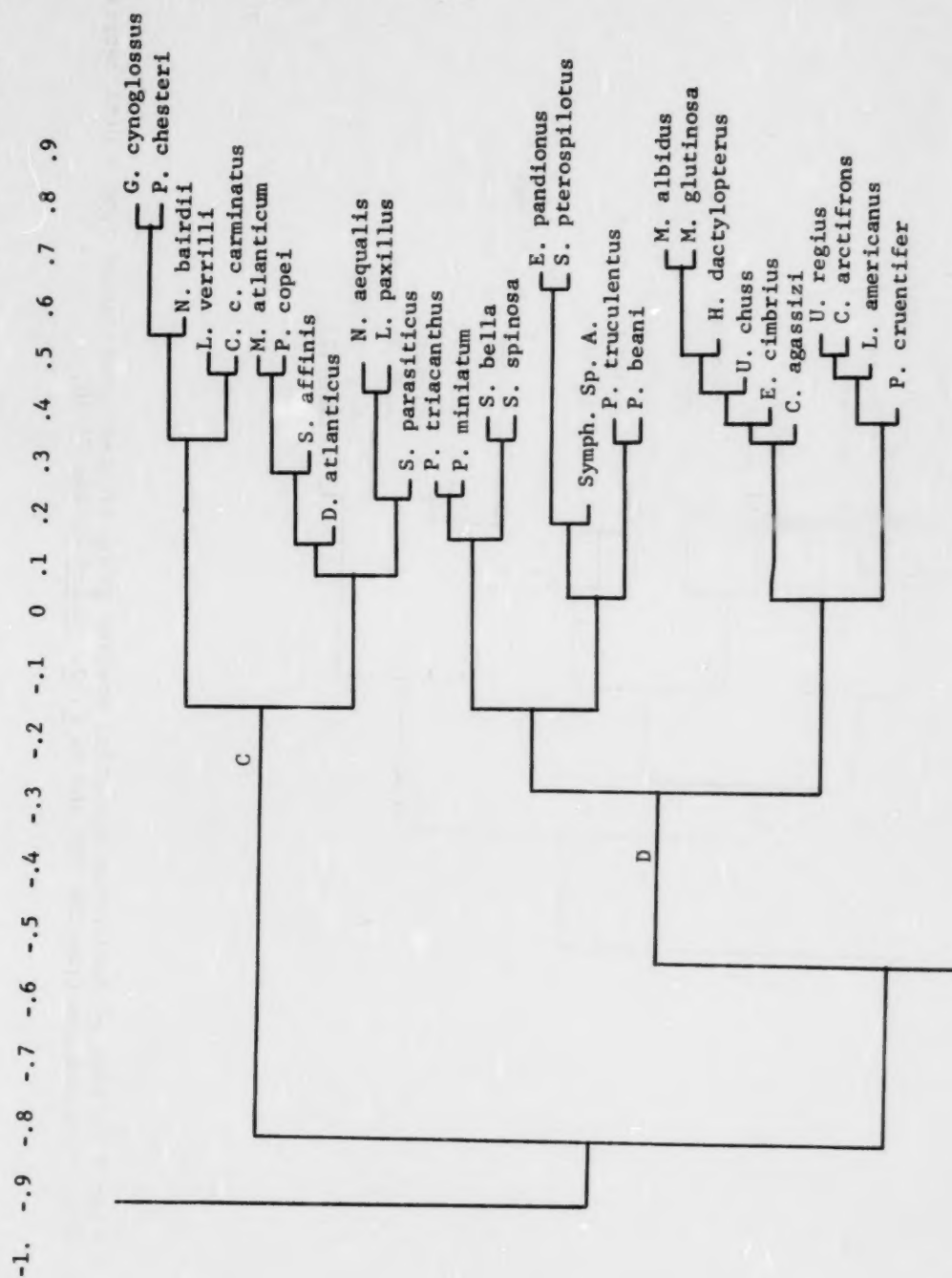


Figure 7.--Central section of dendrogram depicting species group clusters constructed from a data matrix including trawl catches from DWD 106 and RV C. O. Iselin cruise 73-10.

Table 2.--Rank by numerical abundance of the five most dominant species at each DWD-106 trawl station. Stations arranged by increasing depth.

Sta	1	2	3	4	5	6	Number of Specimens	Number of Species
2	S. kaupi	28 N. bairdii	15 G. cynoglossus	13 L. paxillus	2 C. rupestris	1	526	19
3	N. bairdii	18 A. phalacra	17 C. carapinus	15 S. kaupi	10 D. intronigra	8	205	21
3B	N. bairdii	31 S. kaupi	18 A. agassizii	13 A. rostrata	13 D. intronigra	12	223	18
3A	A. rostrata	41 S. kaupi	29 N. bairdii	14 R. bathyphila	5 C. carapinus	5	42	8
4B	A. rostrata	45 C. carapinus	17 H. macrochir	12 A. agassizii	6 P. miles	5	160	18
ALV2	A. rostrata	36 C. armatus	21 H. macrochir	18 C. carapinus	10 A. agassizii	8	39	8
4C	C. armatus	38 H. macrochir	24 A. rostrata	10 P. miles	10 several	5	21	8
5	C. armatus	64 C. carapinus	8 A. rostrata	8 X. myersi			11	4
6B	C. armatus	62 C. carapinus	12 H. macrochir	12 A. rostrata	12 C. leptolepis	4	26	5
6A	C. armatus	89 I. brunneus	11				9	2
5A	B. richardsoni	100					1	1
6	C. armatus	100					1	1

Table 3.--Rank by biomass (fresh wet weight) of the five most dominant species at each DWD-106 trawl station. Stations arranged by increasing depth.

Sta	1	2	3	4	5	6	Total Biomass (kg)
2	S. kaupi	43 U. tenuis	14 C. rupestris	14 G. cynoglossus	9 N. bairdii	9	19,459
3	A. rostrata	24 N. bairdii	20 C. rupestris	15 A. agassizii	14 S. kaupi	12	12,958
3B	N. bairdii	26 A. rostrata	23 A. agassizii	22 S. kaupi	12 D. intronigra	5	24,365
3A	A. rostrata	49 S. kaupi	23 C. rupestris	18 N. bairdii	7 A. agassizii	2	6,827
4B	A. rostrata	69 A. agassizii	8 H. macrochir	8 N. stomias	5 C. armatus	2	55,523
ALV2	A. rostrata	49 C. armatus	15 A. agassizii	10 H. macrochir	10 H. affinis	8	16,610
4C	C. armatus	47 A. rostrata	25 H. macrochir	19 H. raleighana	4 B. richardsoni	2	9,004
5	C. armatus	80 A. rostrata	16 C. carapinus	3 X. myersi			3,982
6B	C. armatus	50 A. rostrata	29 H. macrochir	11 C. leptolepis	6 C. carapinus	5	8,650
6A	C. armatus	98 I. brunneus	2				1,625
5A	B. richardsoni	100					426
6	C. armatus	100					400

Table 4.--Rank by numerical abundance of the five most dominant species at trawl stations deeper than 900m from cruise CI-73-10.

than 900m from cruise CI-73-10.													
Depth (m)	Sta	1	2	3	4	5	6	Number of Specimens	Number of Species				
986	83	G. cynoglossus	23	C. rupestris	23	N. bairdii	21	N. equalis	10	P. chesteri	10	120	11
11194	57	D. intronigra	27	G. cynoglossus	21	N. bairdii	14	G. rupestris	9	A. Pnialacra	7	44	12
1350	97	S. kaupi	34	D. intronigra	23	A. rostrata	12	C. carapinus	6	N. bairdii	4	350	24
1488	90	C. carapina	24	S. kaupi	23	L. atlanticus	11	I. brunneus	10	A. rostrata	8	74	12
1591	95	A. rostrata	52	S. kaupi	13	C. carapinus	7	A. agassizii	6	H. macrochir	3	229	21
1678	96	A. rostrata	56	S. kaupi	18	C. carapinus	9	A. agassizii	6	H. macrochir	4	202	13
1719	91	A. rostrata	27	C. carapinus	21	S. kaupi	6	R. bathyphila	6	others	6	34	13
1876	92	C. carapinus	50	A. rostrata	3	A. lukkeni	13					8	3

Table 5.--Rank by numerical abundance of the five most dominant species at trawl stations deeper than 900 m, north of Cape Hatteras, from RV Eastward cruises E-5-72, E-1-73, and E-2-75.

Depth (m)	Sta	Cruise Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300	301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360	361	362	363	364	365	366	367	368	369	370	371	372	373	374	375	376	377	378	379	380	381	382	383	384	385	386	387	388	389	390	391	392	393	394	395	396	397	398	399	400	401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416	417	418	419	420	421	422	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437	438	439	440	441	442	443	444	445	446	447	448	449	450	451	452	453	454	455	456	457	458	459	460	461	462	463	464	465	466	467	468	469	470	471	472	473	474	475	476	477	478	479	480	481	482	483	484	485	486	487	488	489	490	491	492	493	494	495	496	497	498	499	500	501	502	503	504	505	506	507	508	509	510	511	512	513	514	515	516	517	518	519	520	521	522	523	524	525	526	527	528	529	530	531	532	533	534	535	536	537	538	539	540	541	542	543	544	545	546	547	548	549	550	551	552	553	554	555	556	557	558	559	560	561	562	563	564	565	566	567	568	569	570	571	572	573	574	575	576	577	578	579	580	581	582	583	584	585	586	587	588	589	590	591	592	593	594	595	596	597	598	599	600	601	602	603	604	605	606	607	608	609	610	611	612	613	614	615	616	617	618	619	620	621	622	623	624	625	626	627	628	629	630	631	632	633	634	635	636	637	638	639	640	641	642	643	644	645	646	647	648	649	650	651	652	653	654	655	656	657	658	659	660	661	662	663	664	665	666	667	668	669	670	671	672	673	674	675	676	677	678	679	680	681	682	683	684	685	686	687	688	689	690	691	692	693	694	695	696	697	698	699	700	701	702	703	704	705	706	707	708	709	710	711	712	713	714	715	716	717	718	719	720	721	722	723	724	725	726	727	728	729	730	731	732	733	734	735	736	737	738	739	740	741	742	743	744	745	746	747	748	749	750	751	752	753	754	755	756	757	758	759	760	761	762	763	764	765	766	767	768	769	770	771	772	773	774	775	776	777	778	779	780	781	782	783	784	785	786	787	788	789	790	791	792	793	794	795	796	797	798	799	800	801	802	803	804	805	806	807	808	809	810	811	812	813	814	815	816	817	818	819	820	821	822	823	824	825	826	827	828	829	830	831	832	833	834	835	836	837	838	839	840	841	842	843	844	845	846	847	848	849	850	851	852	853	854	855	856	857	858	859	860	861	862	863	864	865	866	867	868	869	870	871	872	873	874	875	876	877	878	879	880	881	882	883	884	885	886	887	888	889	890	891	892	893	894	895	896	897	898	899	900	901	902	903	904	905	906	907	908	909	910	911	912	913	914	915	916	917	918	919	920	921	922	923	924	925	926	927	928	929	930	931	932	933	934	935	936	937	938	939	940	941	942	943	944	945	946	947	948	949	950	951	952	953	954	955	956	957	958	959	960	961	962	963	964	965	966	967	968	969	970	971	972	973	974	975	976	977	978	979	980	981	982	983	984	985	986	987	988	989	990	991	992	993	994	995	996	997	998	999	1000	1001	1002	1003	1004	1005	1006	1007	1008	1009	1010	1011	1012	1013	1014	1015	1016	1017	1018	1019	1020	1021	1022	1023	1024	1025	1026	1027	1028	1029	1030	1031	1032	1033	1034	1035	1036	1037	1038	1039	1040	1041	1042	1043	1044	1045	1046	1047	1048	1049	1050	1051	1052	1053	1054	1055	1056	1057	1058	1059	1060	1061	1062	1063	1064	1065	1066	1067	1068	1069	1070	1071	1072	1073	1074	1075	1076	1077	1078	1079	1080	1081	1082	1083	1084	1085	1086	1087	1088	1089	1090	1091	1092	1093	1094	1095	1096	1097	1098	1099	1100	1101	1102	1103	1104	1105	1106	1107	1108	1109	1110	1111	1112	1113	1114	1115	1116	1117	1118	1119	1120	1121	1122	1123	1124	1125	1126	1127	1128	1129	1130	1131	1132	1133	1134	1135	1136	1137	1138	1139	1140	1141	1142	1143	1144	1145	1146	1147	1148	1149	1150	1151	1152	1153	1154	1155	1156	1157	1158	1159	1160	1161	1162	1163	1164	1165	1166	1167	1168	1169	1170	1171	1172	1173	1174	1175	1176	1177	1178	1179	1180	1181	1182	1183	1184	1185	1186	1187	1188	1189	1190	1191	1192	1193	1194	1195	1196	1197	1198	1199	1200	1201	1202	1203	1204	1205	1206	1207	1208	1209	1210	1211	1212	1213	1214	1215	1216	1217	1218	1219	1220	12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Patterns of diversity, species richness, and biomass distribution. Species diversity as measured by the information theoretical measure H^1 (Lloyd, Zar, and Karr, 1968) has been computed for DWD-106, Iselin, and Eastward trawl catches and plotted against depth in figure 9. Diversity on the slope was higher and less variable than on the continental shelf.

Species richness as measured by Margalef's (1951) index

$$d = (S-1)/\log_e N$$

has been plotted against depth in figure 10. The pattern of species richness was very similar to that of H^1 diversity.

Biomass as expressed by the $\log_{10}$ of the total weight (gm) of each catch has been plotted in figure 11. There was a marked increase in biomass at the shelf-slope break (ca. 200 m) and also a decrease in variability of biomass. There was a marked decrease in biomass below 2000 m.

Numerical abundance, expressed as $\log_{10} (X+1)$ (where X = total number of individuals captured) has been plotted in figure 12 for those stations deeper than 150 m. There is a pronounced trend toward a proportional decrease in numerical abundance with depth.

Ancillary information. Pelagic fishes incidentally captured at DWD-106 bottom-trawl stations are listed in Appendix A.

DISCUSSION

Faunal assemblages. The cluster analyses show that with the exception of the three deepest, most DWD stations clustered closely with Iselin stations, indicating that similar faunal assemblages were sampled. Sub-group A_1 included the three deepest DWD stations which were located outside the dumpsite in deeper water. They were unique because of their extremely depauperate nature, although the species captured, Coryphaenoides armatus, Illyophis brunneus and Bathyraja richardsoni, occur in shallower water on the lower slope and are clustered with species group B (or A for I. brunneus). The question is whether the apparent depauperate nature of the fauna below 2700 m is real or whether it is an artifact of sampling error. None of the Eastward or Iselin stations were made at these depths (2700 m), but on a recent cruise of RV Gilliss GI-74-04 at Norfolk Canyon in November 1974 (Musick, unpublished data) stations were made at 2624, 2650, and 2752 m (station numbers 87, 75, and 86, respectively). The species composition, diversity, and biomass at these stations were quite similar to those recorded at DWD stations between 2300 and 2700 m. Because DWD 5A, 6, and 6A were made on the periphery of the rad. dumpsite, it is possible that the extremely depauperate catches there were related in some way to radiation. Perhaps the final report of Robert Dyer (EPA) will provide more information on the subject.

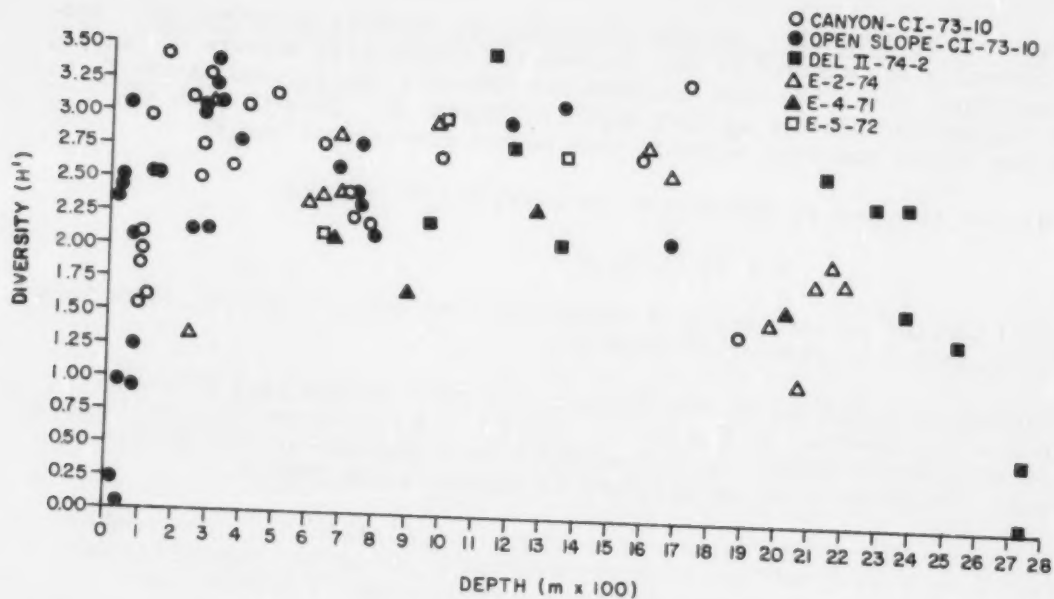


Figure 9.--Diversity (H') plotted against depth for trawl stations made on RV C. O. Iselin cruise 73-10, RV Eastward cruises E-4-71, E-5-72, and E-2-74, and FRS Delaware II cruise 74-2.

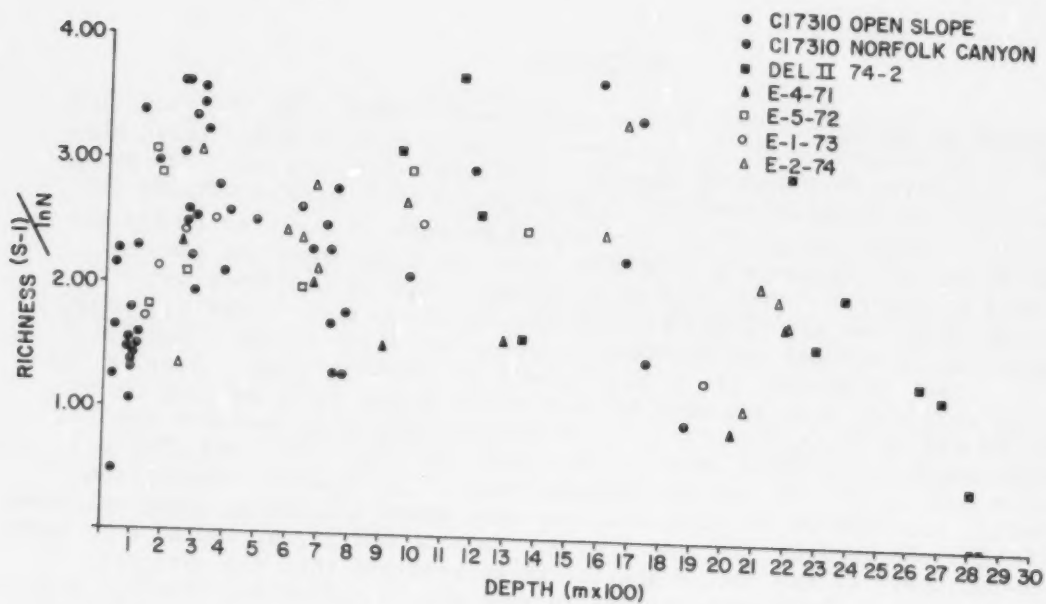


Figure 10.--Species richness plotted against depth for trawl stations made on RV C. O. Iselin cruise 73-10, RV Eastward cruises E-4-71, E-5-72, E-1-73, and E-2-74, and FRS Delaware II cruise 74-12.

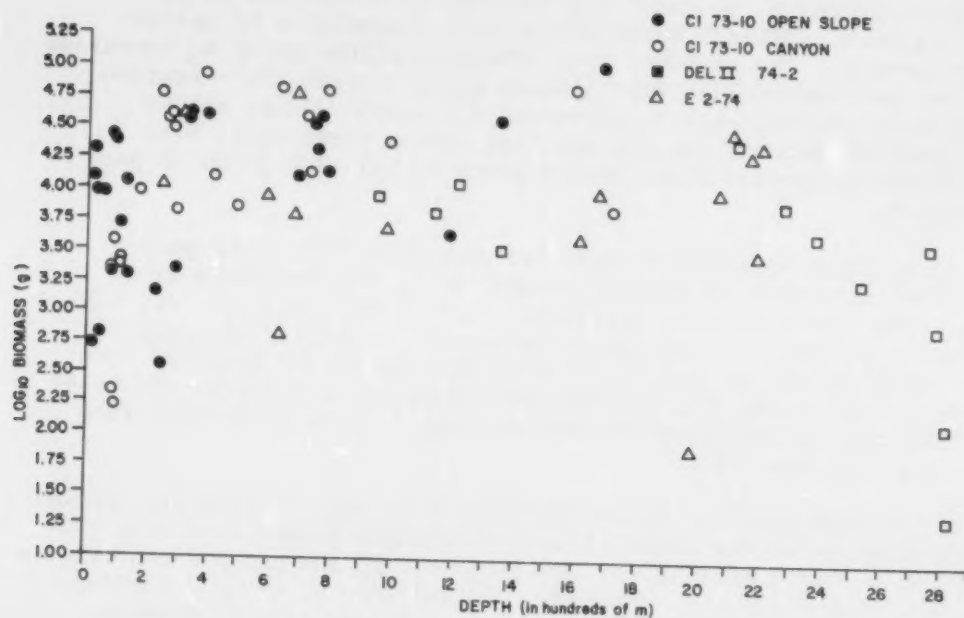


Figure 11.--Log₁₀ of biomass (wet weight) of trawl catches made on RV C. O. Iselin cruise 73-1, RV Eastward cruise E-2-74, and FRS Delaware II cruise 74-2.

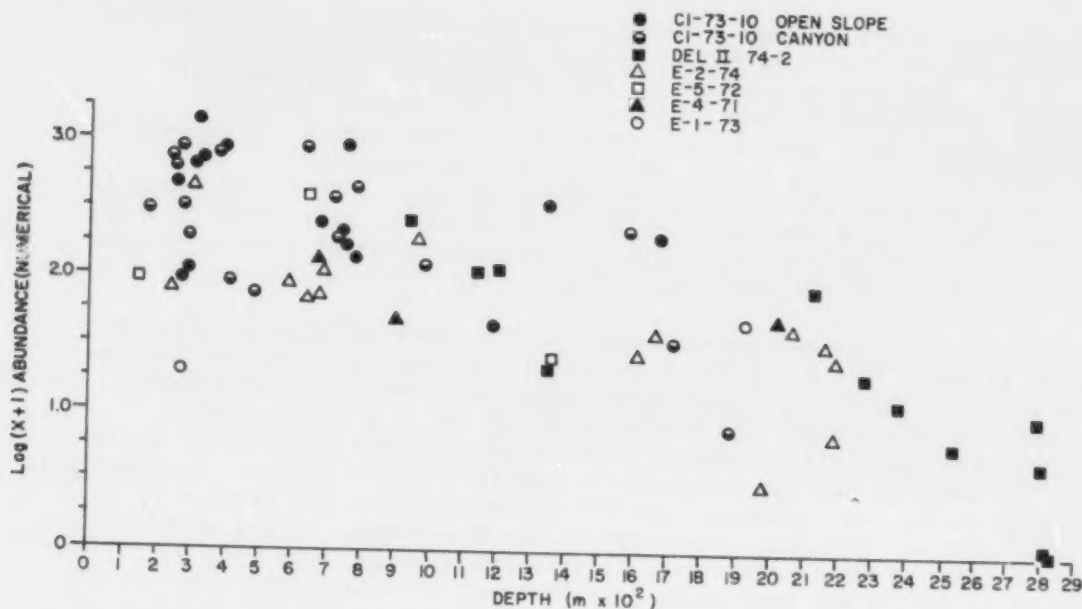


Figure 12.--Numerical abundance expressed as $\log_{10} (X + 1)$ where X = total numbers of individuals captured at each station plotted against depth for RV C. O. Iselin cruise 73-10, RV Eastward cruises E-4-71, E-5-72, E-1-73, and E-2-74, and FRS Delaware II cruise 74-2.

Three species groups A, B, and C are represented within the sites clustered in figure 4. Table 6 shows the percent composition by species group at each station. The stations that clustered within group A₃ contained more than 65 percent individuals from species group B (with the exception of station 92 which yielded only 8 specimens of demersal fishes and 63 pelagics, suggesting that the net did not fish bottom properly). Site group A₃ contained no species from species group C, but as high as 34 percent from group A.

Site group A₂ (fig. 4) branches into two subgroups that correspond closely with the occurrence of species groups and also with bathymetric distribution. The upper subgroup (stations 97, W33, W02, W03, 57, 91, W3A) contains 59 to 91 percent of individuals belonging to species in group A, 5 percent or fewer of "B" species and 6 to 31 percent of "C" species. The lower subgroup (stations 90, 95, 96, W4B, WA2) contains a majority (56 to 92 percent) of individuals belonging to species group A, 8 to 44 percent from group B and virtually none from C.

Comparing site and species cluster patterns with depth (table 6), species group C contributes about one-third of the individuals to stations from 900 to about 1200 m. Group A contributes about two-thirds and group B contributes less than 5 percent. Between 1200 and 1400 m, group C declines drastically in importance and group A increases. Beyond 1400 m, group C is virtually absent. Group A contributes about 90 percent and B about 10 percent of the individuals between 1400 and 1900 m. Beyond 1900 m group B increases and A decreases in importance to about 2300 m and deeper where individuals in species group B outnumber those in group A.

Similar patterns of faunal distribution are reflected by the numerical dominance (tables 2-5). At 900 m, Nezumia bairdii, Glyptocephalus cynoglossus, Lycenchelys paxillus, Phycis chesteri and Coryphaenoides rupestris and Synaphobranchus kaupi are the most dominant species. Synaphobranchus kaupi remains as a dominant to about 1700 m, N. bairdii to about 1400 m, L. paxillus and P. chesteri only to about 1000 m, G. cynoglossus to about 1300 m and C. rupestris to about 1200 m. Aldrovandia phalacra appears as a dominant within a limited bathymetric range of about 950 to 1200 m. Dicrolene intronigra is among the dominant species between 1000 and 1600 m, but reaches higher ranks between 1100 and 1350 m.

Antimora rostrata may appear among the five most dominant species as shallow as about 1000 m and first appears in the top three out of five between 1300 to 1700 m. Coryphaenoides carapinus shows a similar pattern. Both species remain among the dominants to depths of at least 2700 m. Alepocephalus agassizii becomes a dominant as shallow as 1200 m and occurs among the dominant species regularly to depths of about 2200 m. Halosaurus macrochir appears as a dominant species at about 1600 m and remains so to at least 2700 m. Coryphaenoides armatus was the deepest living of the major dominant species encountered in this study, first appearing as a dominant at 2065 m and increasing in importance to about 2300 m, where it replaced A. rostrata as most abundant fish. It remained in this position at all deeper stations excepting DWD station 5A where one specimen or Raja richardsoni was captured.

Table 6.--Percent of total number that individuals of species groups A, B and C contributed to each station in three site groups. Station numbers with the prefix "W" are from Delaware II 74-2 cruise; other stations are from CI-73-10.

Site group	Station	% species Group A	% species Group B	% species Group C	Depth (m)
A2 (upper)	W02	69*	-	31	951
	W03	73	1	26	1143
	57	59	-	41	1194
	W3B	65	3	32	1207
	97	91	1	7	1350
	W3A	78	4	12	1353
	91	74	3	6	
	90	90	10	-	1488
	95	91	9	-	1591
	96	92	8	-	1678
A3	W4B	68	26	< 1	2130
	W4A	56	44	-	2286
	92	88	12	-	1876
	W4C	24	76	-	2372
	W05	30	70	-	2620
	W6B	34	66	-	2700
A1	W6A	11	89	-	2750
	W5A	-	100	-	2750
	W06	-	100	-	2750

* Percentages do not add up to 100 at all stations because very rare species had to be eliminated from the cluster analysis and a few small clusters of remaining rare species were not designated with a species group letter.

The patterns of dominance shown by the RV Eastward data (table 5) were remarkably similar to those reflected in the Iselin and DWD-106 data which were collected with a larger net. This suggests that the relative sampling efficiency for the two nets is about the same for most of the dominant species although because of its smaller size the 30-foot net usually yielded fewer individuals, lower biomass, and a less diverse catch than that of the 45-foot net at similar depths (figs. 9, 10, 11, 12).

Coryphaenoides rupestris was rare in the 30-foot net catches and dominant in some 45-foot net catches. This species actively migrates into mid-water to feed (Savvatinskii, 1969; Haedrich, 1974) and probably more easily avoids the 30-foot net which has a lower headrope.

Both the cluster analyses and the numerical dominance data suggest that these species assemblages should not be viewed as discrete communities separated into zones, but rather as parts of a biocoenose that gradually changes along an ecocline. The faunal gradient appears to be steeper between 1200 and 1400 m and between 1900 and 2200 m.

The concept of a biocoenotic gradient is reinforced by the examination of the bathymetric distribution of individual species. In species group C, the depth range and modal depth of capture for Nezumia bairdii were 166 to 1354 m and 802 m, respectively; for G. cynoglossus they were 166 to 1350 and 643 m; and for P. chesteri, 166 to 1194 m and 597 m. In group B, Halosauropsis macrochir had a range of 1488 to 2379 m and a mode of 1979 m. Bathysaurus agassizi had a range of 1350 to 2288 m, and mode of 1835 m. Coryphaenoides armatus had a range of 2196 to 2745 m (the deepest station sampled) with a mode of 2435 m. Within group A, S. kaupi had a range of 316 to 2196 m with mode of 996 m. Antimora rostrata had a range of 1142 to 2562 m with a mode of 1661 m and Coryphaenoides carapinus had a range of 1142 to 2500 m, with mode of 1679 m. Dicrolene intronigra had a range of 716 to 1591 m, and a mode of 1223 m.

The concept of a biocoenose in an ecocline is at variance with Menzies, George, and Rowe (1973) who proposed a rather rigid system of faunal zonation on the slope, rise, and abyssal plain off North Carolina. Their conclusions were based primarily on isopods (detritovores) and our differences in concept may be based on the analysis of data from different taxa and different trophic levels. However, Dayton and Hessler (1972) said of detritovores "deep sea species show strong depth zonation with the only major zonal break in community composition occurring at the continental shelf-slope transition band." Otherwise there is a continuous turnover in the species composition of the community as depth increases."

This last interpretation of community change is much closer to ours. Both Menzies et al. (1973) and Dayton and Hessler (1972) included some collections in their analyses from deeper areas than sampled by us for fishes.

Distribution of biomass and numerical abundance with depth. Figure 11 shows that the biomass of fishes increased at the shelf-slope break (ca 200 m) then remained fairly constant down to a depth of about 2200 m beyond which a rapid decrease in biomass occurred. This pattern is similar to that which has been documented many times for the distribution of invertebrates but most recently by Rowe, Polloni, and Horner (1974). Hessler (1974) has succinctly paraphrased John Murray's conclusion that standing crop is inversely correlated with depth of water and distance from major land masses, a condition that Rowe et al. have noted is merely a reflection of productivity.

Figure 12, the distribution of numerical abundance of fishes with depth, shows after an initial increase from shelf to slope, a steady decrease in abundance down to about 2200 m where the rate of decrease becomes very pronounced. The difference between the patterns of biomass and numerical abundance distribution above 2200 m is primarily due to the relative decrease in numerical dominance of smaller numerous animals such as Chlorophthalmus, Helicolenis, Synagrops, Lycenchelys, etc., as one proceeds down slope and the increasing dominance of larger species Synaphobranchus, Antimora, etc. Thus fewer individuals may contribute as much biomass. Both biomass and numerical abundance show a sudden decrease at 2200 m.

Distribution of diversity and related parameters. Diversity (H^1) and species richness both reflect the same pattern shown by the biomass distribution, a marked increase at slope break, relative stability down to about 2200 m and a rapid decline thereafter. Our data substantiate the tentative conclusions reached by Markle and Musick (1974) that diversity of fish communities on the continental slope is higher than that of estuarine and shelf communities. Sanders (1968) and his colleagues have amply demonstrated that the diversity of deposit feeding invertebrates is much higher on the continental slope than on the adjacent continental shelf. Hessler (1974) has shown that high diversity in the benthic infauna continues out onto the abyssal plain, a pattern unlike that shown by fishes. Dayon and Hessler (1972) suggested that high species diversity among deepsea deposit feeders was attributable to cropping pressure from predators that kept infaunal populations low, not resource limited, and less likely to encounter competitive exclusion. As a corollary they suggested that the larger the animal, the greater the probability of resource limitation and therefore the lower the diversity of populations of increasingly large animals. Our data support their contention. At about 2200 m, the approximate boundary between continental slope and rise, biomass, and diversity change rapidly and species dominance and composition also change. This change probably coincides with the region at which the benthic communities become predominantly dependent on food sources of oceanic origin.

Commercial fisheries. Currently there are no ongoing fisheries for demersal fishes within the confines of DWD 106 (a seasonal commercial long-line fishery by both Japanese and U.S. fishermen may occur in the area). Of the dominant finfishes, Glyptocephalus cynoglossus supports a fishery elsewhere. This species uses the continental slope for a nursery area and occupies shallower water when adult. Markle (1975) working with data from Norfolk Canyon has suggested that G. cynoglossus off the middle Atlantic states are derived from spawning stocks to the north. It is not known what

percent if any of the large number of juveniles that occur off the middle Atlantic states return to the northern spawning (and fishing) areas.

Of the dominant species which occur within DWD 106, the macrourid, Coryphaenoides rupestris has been exploited by Soviet fisheries to the north and alepocephalids (including A. agassizi or close relations) have been experimentally harvested (Pechenik and Troyanovski, 1970). In addition, C. rupestris and Alepocephalus bairdii have been experimentally harvested off the British Isles by the United Kingdom (Ann, 1974). Both the Soviets (Savvatimskii, 1969) and the British (Ann, 1974) consider the Alepocephalids to be poor quality food fishes because of the high water content of the flesh. Coryphaenoides rupestris, however, is considered to be a high quality food fish. Examination of Norfolk Canyon data suggests that the modal size of C. rupestris in our collections is about 2/3 to 1/2 that of the fish commercially harvested by the Soviets off Newfoundland and Labrador (55-75 cm TL). In addition, the Soviets report average catches in excess of 20 metric tons per trawler hour. The highest catches of C. rupestris recorded from DWD 106 were 2.68 and 1.9 kg per hr and from CI-73-10 were 8.0 and 7.0 kg per hr.

The difference in catch rates is due to the much larger nets that the Soviets use and also the fact that they were fishing for concentrations of C. rupestris located by echo sounder.

In addition the Soviet fishery was most active in July-Oct when concentrations of larger grenadiers migrated upslope from deep water and became available to their gear (Pechenik and Troyanovski, 1971). It is interesting that the Soviets found that in June on the northern Newfoundland Bank and off South Labrador, the C. rupestris are 23-50 cm TL, a size range much closer to that found by us at about the same time of year off the Middle Atlantic States.

Preliminary analysis of the November 1974 cruise on RV Gilliss (Musick, unpublished data) shows catch rates of C. rupestris in the Norfolk Canyon area as high as 1.6 metric tons per hour even with the 45-foot trawl and that the modal size was much larger than that in June. These data suggest that C. rupestris off the Middle Atlantic States may have a seasonal migratory pattern that is similar to that found by the Soviets to the north. Small C. rupestris are available in May or June at about 700 to 1000 m. By November much larger individuals in larger numbers are available at about the same depths and there is a strong possibility that commercially harvestable concentrations occur on the slope off the Middle Atlantic States at that time.

A potentially important decapod resource, the red crab Geryon quinque-dens occurs adjacent to DWD 106. Catch rates of 27.8 and 3.7 kg were recorded at Delaware II stations 2 and 3. The dumpsite itself is mostly deeper than the normal bathymetric range for the species (Haefner and Musick, 1974).

Section II. Reproduction in fishes of DWD 106

C. A. Wenner

Mead, Bertelsen, and Cohen (1964) have pointed out that information concerning modes of reproduction of deep-sea fishes is fragmentary at best. This is due to the paucity of deep-sea trawls both temporally and spatially. This brief account is based on the scant data collected on the Deepwater Dumpsite cruise plus other cruises made to the Norfolk Canyon area.

Anguilliformes

Synaphobranchus kaupi and Ilyophis brunneus, both members of the family Synaphobranchidae, were the eels collected in the greatest numbers on the cruise. Ripe specimens of Synaphobranchus kaupi have been captured year round. Females possess distended abdomens which are filled with oocytes 1 mm in diameter. Histological sections show that these are filled with yolk granules, cytoplasmic lipid vesicles and well developed vitelline membranes. Some males possess swollen testicular lobes filled with mature spermatozoa. Nine percent of the specimens of S. kaupi collected in May were ripe. Egg counts for six females are found in table 7.

Table 7.--Fecundity estimates of Synaphobranchus kaupi from May 1974.

Total length (mm)	Number of eggs
390	14,118
405	16,821
435	21,104
450	18,141
570	46,506
620	54,767

Brunn (1937) found that the smallest of the leptocephalus larvae of Synaphobranchus kaupi are most abundant in the Sargasso Sea area. The smallest larvae (>20 mm) were collected in January through March so that spawning must take place somewhat earlier. Based on length frequency distributions, he concluded that the duration of the planktonic larval stage is about 2 years and they obtain a size of about 120 mm.

Since relatively sexually mature individuals have been collected during April, May, June, July, and November, it may be that a certain percentage of the population spawns the year round or a certain stage of sexual maturity

is reached and arrested until the spawning season. Until more comprehensive seasonal bottom sampling and midwater trawls for eggs and larvae are carried out, the puzzle cannot be unraveled.

Ilyophis brunneus is a relatively rare synphobranchid eel and this is reflected in the scant accounts of this species in the literature. ~ Robins (1968) estimated the number of eggs in a 486 mm total length specimen of I. brunneus as 20,000 with a mean egg diameter of 0.78 mm. Ovigerous females were collected by her in January and September, while we have taken them in May, September, and November. In both of these species of synphobranchid eels, the males are smaller than the females at sexual maturity.

Heteromi

The most frequently encountered halosaur, Halosauropsis machrochir, like the Anguilliform fishes, has a leptocephalus larvae whose description is yet to be published. The sexes are separate with sexual dimorphism present in the structure of the olfactory apparatus (McDowell, 1973). The Deepwater Dumpsite cruise resulted in the capture of several gravid and ripening females ranging in gnathoproctal length (GPL) 250 to 280 mm (GPL = the distance from the tip of the lower jaw to the anus, a measurement used because of the fragility of the caudal region). Two ripe females taken from a cruise in June of 1973 contained 19,225 and 22,620 ova of approximately 1.1 to 1.2 mm in diameter. It appears from other cruise results that this species is a spring-summer spawner.

Salmoniformes

Female specimens of the dominant alepocephalid, Alepocephalus agassizi, were all immature and, to date, none of our cruises has resulted in the capture of mature females. Running ripe males, however, with markedly developed testes were observed in June 1973 (Markle, personal communication). The eggs of A. agassizi are probably large at maturity because Mead et al. (1964) reported that other members of the family have egg diameters of up to 3.0 mm. They also stated that alepocephalids are dioecious and oviparous, producing small numbers of relatively large eggs, with larvae developing directly into adolescent stages.

Gadiformes

The blue hake, Antimora rostrata, was the dominant morid collected during the deepwater dumpsite cruise. Gross and histological examination of the gonads of A. rostrata have failed to provide evidence on its spawning season. Specimens collected during April, May, June, and November all had quiescent gonads with ovaries containing 0.1 mm oocytes with no evidence of yolk deposition, vitellogenesis or cytoplasmic activity. Males sampled at these times had inactive testes containing primary and secondary spermatogonia with no spermatogenic activity.

Data from previous cruises point to a predominance of one sex in any given trawl. Results for the Deepwater Dumpsite cruise are tabulated below:

Station	Number of Males	Number of Females
3	5	10
3A	16	1
3B	16	12
6B	0	3
4B	14	55
4C	0	2
ALVIN 2	3	11

The structure of the ovary leads me to believe that Antimora rostrata has a relatively high fecundity of small eggs that probably develop and hatch at some depth in the water column.

The dominant rat-tails (Family Macrouridae) were Nezumia bairdii, Coryphenoides armatus, C. rupestris and C. carapinus. All specimens of these species were immature or resting (no histological evidence of active gametogenesis). Previous cruises and the November 1974 Gilliss cruise have provided the following information on seasonality of three of the species. Nezumia bairdii had developing oocytes with some yolk deposition and formation of the egg membranes. The eggs, however, were still very small and spawning probably does not take place until late winter-early spring in the Norfolk Canyon area. Coryphenoides carapinus and C. rupestris had larger, more developed ovaries and testis in November. Counts, histological examination and egg diameter measurements have not as yet been completed on the November material. Mature or ripening individuals of C. armatus have not been encountered so little can be said of this species.

The ophidioid fish, Diciolene intronigra, is an oviparous species (Mead et al., 1964) which has sexual dimorphism in the swimbladder structure (Wenner, unpublished data). Based on gross and histological examination of gonads of specimens from other cruises, this species is probably a late summer-fall spawner. Fecundity estimates have not been made, nor are the larvae known.

The eel-pouts (Family Zoarcidae) form a group of boreal fishes which are frequently encountered in slope and deepwater trawls. The DWD trawls collected several specimens of Lycenchelys paxillus. This species had well developed eggs in June 1973 of 3 mm in diameter. The large eggs are few in number (20 to 40 per individual) and are probably demersal. The sexes show dimorphism in that the males have enlarged cheek muscles and modifications of the cranial osteology which may suggest some type of

parental protection of the fertilized eggs. This species probably has direct development with no pelagic larvae.

Pleuronectiformes

The grey sole, Glyptocephalus cynoglossus, spawns in the Georges Bank region from May to September (Ensunko and Nevinskiz, 1973). The adults occur on the continental shelf whereas the young occur on the continental slope which provides ecological separation of the two life history stages and eliminates competition between the juveniles and the adults (Powies and Kohler, 1970; and Markle, 1975). The pelagic eggs are small in diameter (1.0 to 1.2 mm) and hatching takes place in 7 to 8 days (Bigelow and Schroeder, 1953). Since specimens encountered during the DWD 106 cruise were all juveniles, no reproductive information was collected.

In summary, the dominant fishes collected during the DWD 106 cruise have several modes of reproduction, from the suggested parental guarding of a few large eggs of Lycenchelys paxillus to the broadcast spawning of the eels and halosaurs. More information will be available on reproduction of fishes from the continental slope of the Middle Atlantic States after data collected during the RV Columbus Iselin, the RV James T. Gilliss and the RV Eastward and future scheduled cruises have been fully analyzed.

Section III. Food Habits of Fishes of DWD 106

G. R. Sedberry

INTRODUCTION

Little is known of the food of deeper dwelling demersal fishes of the continental slope and rise and of the abyss (Marshall, 1965; Bright, 1970; Grassle and Sanders, 1973) and few studies have dealt with trophic structure in the deep sea. Food of some deep living invertebrates and fishes has been reported by Marshall (1954), who reviewed the two main theories of food provision to the deep sea: the rain of dead plankton (Agassiz, 1888) and vertically migrating food chains (Vinogradov, 1953 as cited by Vinogradov, 1961). Vinogradov (1961), in looking at the feeding patterns of deep-sea zooplankton, proposed that overlapping vertical migrations were the most likely mechanism of food transport from the productive surface waters down to great depths. Menzies (1962) again reviewed the theories of sources of food and, from his data on isopods and the literature, proposed that the rain of dead plankton was the most important food source. Additional work on this problem and the food of deep-sea invertebrates has been reported by Krogh (1934), Issacs (1969), Sanders and Hessler (1969), Harding (1973), Dayton and Hessler (1972), Grassle and Sanders (1973), and others (see Zenkevich and Birstein, 1956 for earlier studies).

Food of deep-sea pelagic fishes has received some attention in recent years (Marshall, 1954; Haedrich, 1964; Haedrich and Nielson, 1966; Duka, 1969; Collard, 1970; Childress and Meek, 1973; and others; see Merrett and Roe, 1974 for review).

As far as benthic and benthopelagic (Marshall, 1967) fishes are concerned, less work has been done. Stomach contents of some species have been reported only in passing in taxonomic and other works (Bigelow and Schroeder, 1953; Marshall, 1954; Cohen, 1958; Nielson, 1964; Marshall, 1965; Bright, 1968; Robins, 1968; Marshall and Iwamoto, 1973; McDowell, 1973), and hence are based on a few specimens and are consequently incomplete. Bright (1970) examined the stomachs of many species of deep-sea fish from the Gulf of Mexico and constructed a food web from his data, but his material was limited to 81 small specimens. Clarke and Merrett (1972) discussed the significance of pelagic food in the stomachs of deep living benthic fishes they examined. Haedrich and Henderson (1974) and Percy and Ambler (1974) studied the food habits of macrourids of the genus Coryphaenoides.

Dayton and Hessler (1972) predicted that deep-sea benthic fishes should be extreme food generalists, preying on populations of smaller deposit feeders and thus maintaining a high diversity in deposit feeders by reducing the probability of competitive exclusion. Sanders (1968) and Grassle and Sanders (1973) speculated that deep-sea benthic carnivores are not complete generalists, but would be expected to be specialized feeders. They admitted data were lacking to support them.

The purpose of this report is to describe the food habits of several species of fishes from the continental slope and rise and to provide a clearer picture of trophic structure in these habitats and to evaluate the role of fishes in maintaining the high diversity of the deep-sea benthic fauna.

METHODS

Stomachs of several specimens of different dominant species were excised onboard and preserved in 10% seawater formalin for later analysis. Fishes and organisms which could possibly serve as food for the fishes were also collected and subjected to radiological analysis by EPA personnel onboard.

Most fishes from these depths regurgitate their food when hauled up because of expansion of gas in the swimbladder. Consequently, only a limited number of stomachs could be examined from Delaware II cruise. In all, nine species of fishes were examined. For each stomach, the contents were emptied, identified, sorted and the number of stomachs in which an item occurred noted and expressed as a percentage of the number of stomachs examined (frequency of occurrence, FO). The number of individuals of a food item were counted and expressed as a percentage of the total number of food items (numerical dominance, ND). Volume of the total number of food items of a given taxon was measured by displacement and expressed as a

percentage of the total volume of the stomach contents (volume displacement, VD). Volume displacement of sediment was also noted as an indication of the amount of benthic feeding occurring. For purposes of this analysis, fragments of an animal were counted as one organism. For example, if crustacean fragments occurred in a stomach, it would be counted as one unidentified crustacean. A total of 43 stomachs were examined, of which four were completely empty.

RESULTS

Halosauropsis macrochir

Twenty-five stomachs of H. macrochir were collected from three stations (15 from 4B, 3 from 6B, and 7 from ALVIN 2). Only one of them was completely empty. Crustaceans were the dominant food item in frequency of occurrence (64 percent of stomachs examined), number of individuals (77.4 percent of the total number of individual food items), and volume displacement (16.9 percent of the total food volume). Within the crustacean group, unidentified crustacean fragments occurred in the greatest number of stomachs (FO = 28%) followed by amphipods (FO = 24%) and isopods (FO = 20%). Amphipods were the numerically dominant food item (NC = 25.8%), followed by unidentified crustaceans (ND = 22.6%) and isopods (ND = 16.1%). Volumetrically, decapod crustaceans had the greatest volume displacement (VD = 10.9%), followed by unidentified crustaceans (VD = 2.6%) and isopods (VD = 9%).

Other dominant food items included ophiuroids (FO = 12%, ND = 9.7%, VD = .8%), poriferan (sponge) fragments (FO = 8%, ND = 6.5%, VD = 1.0%), and calanoid copepods (FO = 8%, ND = 6.5%, VD = .4%). Polychate fragments and holothurian fragments were of minor importance, appearing on only one stomach.

It is apparent from this data and other studies (McDowell, 1973) that H. macrochir feeds mainly in the sediment. Sediment occurred in 68 percent of all stomachs examined and comprised 74.9 percent of the volume of the stomach contents. Some of the amphipods found in the stomachs (Ampelisca, Harpinia, and the Lysianassids) are considered to be infaunal, and fragments of ophiuroids, sponges, and holothurians provide evidence for infaunal and epifaunal benthic feeding by H. macrochir. Some pelagic feeding may also occur, as noted by the presence of pelagic shrimps (Hymenopaneus laevis and Sergestes sp.) in two stomachs.

Coryphaenoides armatus

Five stomachs from C. armatus were examined from two stations (1 from 6A, and 4 from ALVIN 2). All five contained identifiable food.

Crustaceans were the most abundant food. All five stomachs contained crustaceans. They comprised 94.6 percent of all individual food items and constituted 76.4 percent of the volume of stomach contents. Within the crustaceans, amphipods had the highest frequency of occurrence, as they occurred in all stomachs examined. Unidentified crustacean fragments were next (FO = 80%), followed by decapods (FO = 60%). The remainder of the crustaceans were comprised of calanoid copepods, valviferan isopods,

and euphausiids (FO = 40% for each). Amphipods were also numerically dominant (ND = 46.4%), followed by decapods (ND = 21.4%), calanoid copepods (ND = 8.9%), and euphausiids (ND = 5.4%). Unidentified crustacean fragments comprised the greatest volume of crustacean food (VD = 44.5%), followed by decapods (VD = 26.1%), amphipods (VD = 3.1% and euphausiids (VD = 1.4%).

The remaining (noncrustacean) stomach contents were mainly cephalopods. Cephalopod remains (Histioteuthis and Thysanoteuthidae) occurred in 40 percent of the stomachs examined, comprised 5.4 percent of the total number of food items, and contributed 3.9 percent to the total volume of food. The remainder of the stomach contents was sediment (VD = 11.3%) and unidentifiable remains, generally a white paste (VD = 5.9%). One stomach also contained pieces of cellophane.

The stomach contents of Coryphaenoides armatus indicate that they are mainly pelagic feeders. This is evident by the abundance of remains of squids, pelagic hyperiid amphipods, euphausiids (Nematoscelis microps and Thysanopoda acutifrons), copepods (Euchirela rostrata), branchyuran megalopae (which are initially pelagic), and other crustacean larvae, and also by the relatively small amount of sediment. This is in agreement with the finding of other investigators (Haedrich and Henderson, 1974; Percy and Ambler, 1974).

Lycodes atlanticus

Four stomachs of specimens of L. atlanticus were examined from three stations (1 from 3, 2 from 3B, and 1 from 4B). Bivalve mollusks and ophiuroidean echinoderms were the predominant food found in L. atlanticus stomachs examined. Bivalves (Hyalopecten sp., Lyonsiella sp., Malletia polita) occurred in 75 percent of the stomachs and comprised 72.7 percent of the total number of food items. Being rather small in size, they comprised only 13.4 percent of the total volume of stomach contents. Ophiuroideans (Ophiomusium lymani and unidentifiable fragments) occurred in all four stomachs examined and had a numerical dominance of 15.2 percent. They were the most important food item volumetrically with a volume displacement of 22.6 percent. The remainder of the food was composed of polychaete fragments, an amphipod, and a small pycnogonid (Nymphon macrum). Sediment took up most of the volume of the stomachs examined, with a volume displacement of 62.1 percent.

The remainder of species examined are represented by only one or two stomachs and will be summarized together. Of the three Aldrovandia phalacra examined, two were empty and the third contained only a white paste similar to that described by McDowell (1973) from specimens of A. phalacra which he examined. He has termed this "shrimp paste" and concluded that it is probably composed of detritus and crustacean remains. A. phalacra feeds on small benthic and pelagic crustaceans.

The one Simenchelys parasiticus stomach examined contained a large amorphous mass of white paste. Nothing could be recognized as fragments of any particular animal. This is probably fish flesh as these eels are believed to feed by boring into the bodies of other dead or living fishes (Goode and Bean, 1896; Salomon-Raju and Rosenblatt, 1971).

The single stomach of Bathysaurus agassizi examined contained a fish, Halosauropsis macrochir. The two stomachs of Synaphobranchus kaupi examined contained squid (Histioteuthis) and hyperiid amphipod remains. The single specimen of Coryphaenoides rupestris examined contained copepods and crustacean remains. A single stomach of Centroscyllium fabricii was found to be empty.

The limited sampling possible at DWD 106 makes it necessary to include data from other sources in order to describe with any confidence, the food habits and trophic position of dominant fish species. Consequently in the "Discussion" section of the present report I will refer to the results of the analysis of stomachs of 776 fishes in 21 species collected on other cruises cited in Section I (Cruises: CI-73-10, GI-74-04, E-2-74, and E-1-73).

DISCUSSION

Menzies (1962) discussed possible sources of food for deep-sea organisms and ranked these sources in the following order of importance: 1, rain of dead plankton (Agassiz, 1888); 2, turbidity currents (Heezen, Ewing, and Menzies, 1955); 3, living vertical migrations (Vinogradov, 1958); 4, floating benthic marine plants; and 5, floating terrestrial plants (Agassiz, 1892; Brunn, 1957). He also stated that far at sea the rain of plankton may be followed in importance by living vertical migrations, but that in near shore areas there is little doubt that turbidity currents, the rain of dead plankton, and floating terrestrial and marine plants are the major sources of food. He believes that turbidity currents may bring organic rich sediment and near shore estuarine and terrestrial plants and debris to the deeper waters, enriching the food supply. It appears however, that this may not be an important direct source of food for fishes.

Submarine canyons are believed to be high incidence areas for turbidity currents (Heezen, Ewing, and Menzies, 1955), and if they are as important in deep-sea nutrition as Menzies believes, then shallow water plant material and debris should be an important source of food for fishes from canyon areas. There was no shallow water debris in any of the stomachs examined in this study, although other workers have reported small amounts of neritic algae and tracheophytes from deep-living fishes (Haedrich and Henderson, 1974; Percy and Ambler, 1974). This material may have been uprooted by storms and carried out as a "floating benthic marine plant" food source (Menzies, 1962). However, inshore macrophytes are not important in the nutrition of the deep sea (Vinogradov, 1961). Turbidity currents may play an important role indirectly in the nutrition of these fishes by recycling nutrients and increasing productivity of planktonic animals, thus increasing the number of migrating pelagic animals which in turn serve as food for benthic fishes. Populations of detritus feeders such as Meganocyttiphanes norvegica, Thysanopoda acutifrons, and other euphausiids (Macdonald, 1927; Einarsson, 1945; Mauchline, 1959, as cited by Rayment, 1963), may be increased by the action of turbidity currents stirring up organic detritus into suspension. These detritus feeders, in turn, are

important food items for many deep-sea benthic fishes. Turbidity currents, by bringing organic rich sediments to greater depths, may support a greater number of deposit feeders, increasing the food supply for those species of fish that feed heavily on benthic deposit feeders (Halosaurus macrochir, Aldrovandia spp., Lycodes atlanticus, Harriota raleighana). However, available evidence indicates that they are only of minor importance in food transport (Sanders and Hessler, 1969). They may even reduce food supply by destroying the habitat and burying deposit feeders under thick layers of sediments (Heezen, Ewing, and Menzies, 1955).

It is apparent in many dominant slope species examined (Synaphobranchus kaupi and Phycis chesteri) and in a dominant abyssal species (Coryphaenoides armatus), that living vertical migrators are the most important sources of food. The pelagic myctophids, euphausiids, decapods, and cephalopods are the most important items in the diet of these fishes. On the continental slope, where vertical migrations bring mesopelagic animals down to the bottom, this is a very important food source for the dominant fishes, Synaphobranchus kaupi and Phycis chesteri. Other dominant benthic slope fishes, such as macrourids, also feed heavily on vertically migrating animals (Okamura, 1970; Marshall and Iwamoto, 1973). Vertical migrations may be an important source of food for abyssal fishes, such as Antimora rostrata and Coryphaenoides armatus, which had pelagic food items in their guts. Haedrich and Henderson (1974) have also cited Coryphaenoides armatus as a possible example of Vinogradov's vertically migrating food chain.

Menzies (1962) is probably correct in asserting that the rain of dead plankton is the most important food source far at sea. Though these small refractory particles are of little use to fishes directly, in the deeper living fishes examined in this study (Halosaurus macrochir, Lycodes atlanticus, and in some Coryphaenoides armatus), and in stomach contents of fishes reported by other workers (Nielson, 1964; Bright, 1968, 1970), filter and deposit feeding animals are important food items. The dominance of deposit feeders in open areas of the sea is evidence of this type of food supply (Menzies, 1962; Sanders and Hessler, 1969). Rains of small particles thus sustain populations of deposit and filter feeders, which in turn serve as food for many benthic deep-sea fishes, which root in the oozes for food (Halosauridae, Zoarcidae, some Macrouridae, chimaeroids).

This indiscriminate rooting in the ooze and ingesting of sediment and infauna, which many species have exhibited, may also play a role in maintaining the high diversity (Sanders, 1968; Sanders and Hessler, 1969) which is found in deep-sea deposit feeders. Disturbance caused by uprooting and ingestion of infaunal and epifaunal animals by species such as Halosaurus macrochir, Lycodes atlanticus, and Aldrovandia sp. and some macrourids (Marshall and Bourne, 1964) serves as to regulate the population sizes of these prey organisms. This regulation reduces the probability of competitive exclusion, as Dayton and Hessler (1972) have hypothesized. The cropping life style as described by Dayton and Hessler (1972) is seen in the stomach contents found in this study and in the feeding behavior of these fishes, as described by Marshall and Bourne (1964).

Grassle and Sanders (1973) state that deep-sea benthic carnivores are not complete generalists that prey on smaller species with little selectivity. However, in areas where there is a lower abundance of food, such as the deep sea, fishes should be more generalized feeders (Ivlev, 1961; Schoener, 1971). Studies that have dealt in detail with the food of deep-sea benthic fishes have concluded that the species studied are generalists (Haedrich and Henderson, 1974; Percy and Ambler, 1974). The cropping benthic feeders examined in this study appear to exhibit little selectivity in their feeding. They consume any item which is small enough for them to eat, although no comparison of stomach contents with the benthic fauna can be made. Larger mouthed species (Halosauropsis macrochir, Lycodes atlanticus) consume some larger prey than the smaller mouthed species (Aldrovandia sp.), but there is much overlap. These croppers consumed a wide variety of food, thus having a generalized diet. The stomach contents of Halosauropsis macrochir comprised seven different phyla. Lycodes atlanticus had consumed five phyla of invertebrates and at least 21 species. Aldrovandia sp. fed on four phyla comprising at least 10 species. Stomach analysis of other species of deep living fishes have shown similar results (Bright, 1968, 1970; Haedrich and Henderson, 1974; Percy and Ambler, 1974).

Another indication of generalized feeding is the overlap found in the diets of fishes which co-occur. Phycis chesteri feeds mainly on fishes, decapods, and euphausiids, and Synphobranchius kaupi feeds mainly on fishes, cephalopods, and euphausiids. Of the fishes eaten, Ceratoscopelus maderensis and unidentified myctophids are the most important food for both species of predator. Several species of euphausiids and decapods are common prey to both species. Amphipods are important food items for Halosauropsis macrochir, Aldrovandia sp. Lycodes atlanticus, and Coryphaenoides armatus, with several genera shared as common food.

Benthic fishes which fed mostly on pelagic food items (Synphobranchius kaupi, Phycis chesteri, Antimora rostrata, Coryphaenoides armatus) also had generalized diets, but since they do not feed on deposit feeders, they would not be important in reducing competitive exclusion at this trophic level. Mobile predators such as these may function in dispersing large falls (Issacs, 1969) by consuming them above or on the bottom and homogenizing these widely spaced falls by spreading them out over the bottom as feces as Dayton and Hessler (1972) have hypothesized. The "shrimp paste" found in many stomachs by myself and other workers (McDowell, 1973) may represent scavenged larger parcels of flesh which are in the process of being dispersed over the bottom. Certainly scavengers such as many of the deep-sea sharks and Simenichelys parasiticus function at this trophic level.

Several species of fish consumed large amounts of sediment. Many specimens of Halosauropsis macrochir, Lycodes atlanticus, Harriota raleighana, Hydrolagus affinis, and some Aldrovandia had a greater volume of sediment than food in their stomachs. It is not known how much nutrition is derived from this sediment. McDowell (1973) believed the sediment he found in halosaurs to be "non-nutritional" but gave no evidence for this conclusion.

Section IV. Possible effects of dumping industrial wastes at DWD on demersal fishes

J. A. Musick

During the course of this study we have often heard various colleagues comment on the very low probability of demersal fishes being affected by industrial waste dumping at DWD 106 because of dispersal and dilution of such wastes in the upper water column. To this contention we offer the following cautionary comments.

1. Even though several species have demersal eggs, most of the dominant fishes at DWD 106, (S. kaupi, A. rostrata, the holosaurs and macrourids) have pelagic eggs and larvae that would be exposed to wastes in the upper water column. Particular attention should be given to wastes which form flocculants that might become suspended in the thermocline, an area of concentration for fish eggs and larvae and other zooplankters.
2. Several of the dominant fishes at DWD 106, (A. rostrata, S. kaupi, C. rupestris, C. armatus) feed primarily on pelagic animals. There is evidence that some of these benthopelagic fishes actively forage in the water column and there is also evidence that some species of mesopelagic fishes spend the daylight hours close to the bottom. These facts suggest that there may be relatively rapid pathways for materials from the surface to the bottom even in areas as deep as DWD 106. Of primary concern should be the transport of persistent biologically active compounds (heavy metals, chlorinated hydrocarbons, etc.) dumped at the surface.
3. Because of the relative constancy of the environment on the lower continental slope and rise the resident fishes are probably much more stenobiotic than are fishes of the continental shelf. Consequently caution must be exercised in making any attempt to extrapolate the results of shelf dumping studies to the deep-sea.
4. The northwest corner of DWD 106 is located over the mid-slope, an area of steep bottom gradient and only 21.2 km from the 200-m isobath. Prolonged southerly winds after a dump could quite conceivably cause waste materials to drift onto the upper slope, where the developing red crab fishery would be active or even to the outer shelf where there are several seasonally active fisheries (flounder, porgy, butterfish, lobster by U.S. fishermen; squid and butterfish by the Japanese; squid by the Spanish; hakes by the Soviet block).
5. Tom's Canyon, a small submarine canyon, funnels into the north-west corner of DWD 106 (Coast and Geodetic Survey Chart 0807N-53). Rowe (1972) has recently pointed out that such canyons may trap large aggregates of shallow water detritus and funnel sediment movements into the deep-sea. If such is the case with Tom's Canyon, then DWD 106 would be the recipient of accelerated downslope transport of carbon from the shelf. Consequently DWD 106 might support larger populations (at least of mobile megabenthic organism) than adjacent areas. Our studies in Norfolk Canyon suggest that for fishes, larger individuals are found in the canyon than on the adjacent

slope, and also seasonally the canyon acts as a focal point for the aggregation of Coryphaenoides rupestris. No data exist on the fishes of DWD 106 other than for the spring but because of the presence of Tom's Canyon, the area is a more likely place for aggregations of C. rupestris in the fall than adjacent slope areas.

6. Submarine canyons are areas of active, complex bottom currents (Shepard, Marshal and McLoughlin, 1974). Consequently prediction or interpretation of the dispersal of wastes near the bottom will be more difficult in the northwest corner of DWD 106 than on the adjacent slope.

Section V. Recommendations

It would be naive to assume that contractors transporting wastes to DWD 106 will use the center of the dumpsite for disposal. In order to save time and fuel it is a simple economic fact that most contractors will dump in the shallow northwest corner of DWD 106 closest to land. Consequently dumping will be concentrated in a canyon ecosystem and in an area where there is a likelihood of wind driven dispersal of wastes over the upper slope and outer shelf.

Therefore, we recommend that consideration be given to move the locality of the dumpsite south to about the vicinity of the rad dumpsite. Such a move would place the site entirely on the continental rise away from the influence of Tom's Canyon and the diverse slope ichthyofauna. Diversity and biomass of fishes are lower on the rise. The bottom is well below the mesopelagic zone and even though there still remains the chance of vertical transport through pelagically foraging benthopelagic fishes, the great numbers of the vertically migrating mesopelagic fauna would not reach the bottom. Lastly, macrourids are less important and ophidioids become more important at the depths at which the rad site is located. The ophidioids are viviparous or have demersal eggs. Because fewer species with pelagic eggs and larvae occur in this deeper area than at DWD 106, the potential of industrial wastes affecting benthic fish populations through destruction of eggs and larvae will be reduced. In addition, the chance of encountering pelagic eggs and larvae of commercially important species spawned on the continental shelf will also be reduced.

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APPENDIX A.--Pelagic fishes incidentally captured at DWD-106 bottom trawl stations.

Station #	2	3	3B	3A	4B	ALV2	4C	5	6B	6A	5A	6
Taxon												
Nessorhamphidae												
Nessorhamphus ingolfianus-----												1
Serrivomeridae												
Serrivomer beanii-----	4	2		1								1
Bathylagidae												
Bathylagus berycoides-----												1
Bathylagus sp. A-----												1
Gonostomatidae												
Polymetme corythaeola-----												1
Gonostoma elongatum-----		2				1		3				1
Gonostoma bathyphilum-----		1			1							1
Cyclothone sp.-----												3
Sternoptychidae												
Argyropelecus aculeatus-----			1									1
Sternoptyx diaphana-----												2
Chauliodontidae												
Chauliodus sloanii-----		2										
Stomiatidae												
Stomias boa ferex-----		1		1								
Melanostomiatidae												
Melanostomias valdiviae-----												2
Malacosteidae												
Malacosteus niger-----		1										
Paralepididae												
Macroparalepis affine-----		1										
Myctophidae												
Ceratoscopelus maderenis-----							1	1				1
Lampanyctus macdonaldi-----		1				1						
Melanocetidae												
Melanocoetus murrayi-----												1
Anoplogasteridae												
Anoplogaster cornuta-----		1										
Melamphidae												
Scopelogadus mizolepis-----					1							1
Poromitra crassiceps-----												1
Scopeloberyx robustus-----												1
Scopeloberyx opisthopterus-----												1

AN ANALYSIS OF PLANKTON FROM DEEPWATER DUMPSITE 106¹

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INTRODUCTION

Deepwater Dumpsite 106 (DWD 106) is a 1622-km² (480-nmi²) area beyond the continental shelf off New York. It is used for dumping industrial wastes and certain explosives. The site is bounded by latitudes 38°40' and 39°00'N and longitudes 72°00' and 72°20'W, and has a depth of 2700 m (fig. 1).

During May 1-23, 1974, the National Marine Fisheries Service vessel F R S Albatross IV conducted a survey of DWD 106 and adjacent areas to characterize the region and provide the necessary data to determine the advisability of continued dumping.

This report of the field investigation describes the biological populations of the area and several biological/watermass relationships. It includes: 1) description of displacement volume and dry weight for each sample; 2) fish eggs, fish larvae, and invertebrate plankton abundance (identified to species level for more abundant forms); and 3) a discussion of their distribution and abundance relative to significant oceanographic features. The following technicians and research assistants provided most of the identifications: Ken Tighe and Kim Larson, fish larvae; Bruce Mundy, fish eggs; Tulio Croce, euphausiids; Ron Caplan and Susan Perrit, copepods. Ron Caplan also provided contributions to the discussion. Carol Kearns did the drafting.

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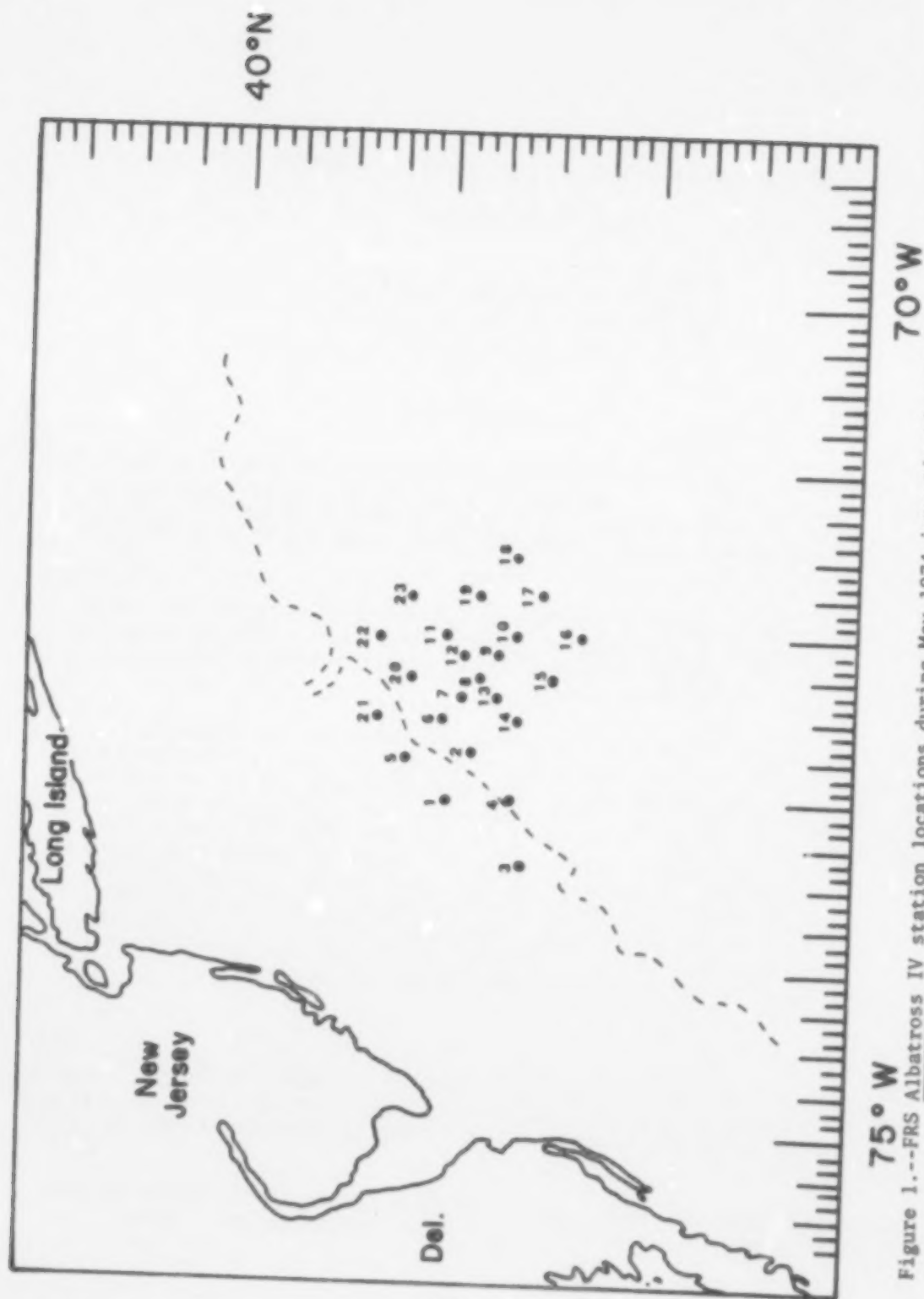


Figure 1.--FRS Albatross IV station locations during May 1974 investigation of Deepwater Dumpsite 106.

METHODS AND MATERIALS

Field Methods. Standard MARMAP³ sampling gear and methods were used to collect plankton samples. Net tows were made with 61-cm Bongo samplers fitted with nets of 0.505-mm and 0.333-mm mesh Nitex. The Bongo samplers, fitted with flowmeters inside each net mouth, were deployed on 0.64-cm wire rope with a 45-kg weight and a time-depth recorder. Double oblique tows were made with a prescribed payout and retrieval rate of 50 m/min and 20 m/min, respectively. The intended maximum depth was to be within 5 m of the bottom, or to a maximum of 200 m. A pilot house reading wire-angle inclinometer was used to continuously monitor wire angle. The speed of the vessel was varied to maintain a wire angle of 45° during haul back. This procedure resulted in an average tow speed of between 1.5 and 2 knots.

The MARMAP neuston net also was towed at each station. It has a rectangular mouth of 1 m by 2 m. The net was towed at the air-seawater interface at a speed of 5 knots for 10 min. The length of the towing wire was adjusted so that the net usually was fishing the upper half meter of water.

All net tow samples were preserved in buffered 5% seawater formalin.

Laboratory Methods. Standard MARMAP⁴ laboratory sorting procedures were followed in the analysis of the plankton samples.

Upon receipt by NYOSL all large nonplanktonic organisms such as squid, extra-biotic debris, and all ichthyoplankton were removed from the samples. The samples were then measured for displacement volume. Displacement volumes were found by measuring the initial volume of the sample and the preserving fluid. Then the contents were poured through a filter cone of plankton netting (202 μ). After the fluid ceased to drip, the volume of the fluid was measured and subtracted from the initial volume, giving the displacement volume of sample. Volumes were determined to the nearest whole milliliter.

The samples were then represerved in new 4% sodium acetate buffered formalin and split using a Folsom splitter. The size of the aliquot was determined on the basis of the volume of the sample. One aliquot was used for sorting and one, of equal size, was sacrificed for dry weight determinations.

3 Details for MARMAP standard plankton gear and sampling methods may be obtained at the MARMAP Field Group, RR7A, Box 522-A, Narragansett, Rhode Island 02882.

4 Details of MARMAP laboratory procedures can be found in MARMAP Survey I Manual (Laboratory Procedures), which can be obtained at the MARMAP Field Group, RR7A, Box 522-A, Narragansett, Rhode Island 02882.

The major taxa (orders were sorted identified to the lowest taxa possible.

Dry weights were measured by drying the aliquot in a Gravity Oven at 100°C for 18 hours. (Weights were measured on a Metler H-20 balance [$\pm .01$ mg.])

Fish larvae and eggs were identified to the lowest taxonomic level possible. Standard lengths were determined to the nearest 0.1 millimeter (mm) for all fish larvae. The total wet weights for each species from the neuston samples were measured on a Metler top-loading pan balance to the nearest .01 gm. Ova and oil drop diameters were measured to the nearest .01 mm. The following references were used for ichthyoplankton identifications: Adams, 1960; Berry, 1959; Berry and Vogele, 1961; Bigelow and Schroeder, 1953; Bohlke and Chaplin, 1968; Colton and Marak, 1969; Fields, 1962; Gibbs, 1959; Gibbs, et al., 1971; Gutherz, 1970; Haedrich and Horn, 1972; Hildebrand and Cable, 1930; Houde, 1972; Kendall, 1972; Legaspi, 1956; LoBianco, 1931-33; McKenney, 1959; McKenney, 1961; Norcross, et al., 1974; Richardson and Joseph, 1973; Scotton, et al., 1973; Scherbachev, 1974; and Smith, 1969 (manuscript).

The volume of water filtered during each Bongo tow was calculated assuming 100% filtration efficiency, and multiplying the area of the mouth opening by the distance towed, the latter obtained from a calibrated meter in the net mouth. Volume filtered by the neuston net was not calculated. Rather the area of sea surface sampled was determined assuming a 2-m wide sampling path for the distance of tow (speed of tow multiplied by duration of tow).

Relative abundance values were calculated for each 1000 m³ of water filtered for Bongo samples and 1000 m² of water sampled for neuston samplers. For those wishing to convert Bongo catches to quantity beneath 10 m² of sea surface the number of organisms captured in a sample must be multiplied by the Standard Haul Factor (maximum depth of tow X 10)/volume filtered. Standard haul factors for each sample are given in table 2.

RESULTS AND DISCUSSION

The upper 100 m Deepwater Dumpsite 106 survey is a region of rapid temporal changes of oceanographic features and of transition from shelf to oceanic conditions. Examination of the monthly field of sea-surface temperatures provided by the Oceanographic Unit of the U.S. Coast Guard shows the area to be characterized by an oceanic thermal front (shelf water/slope water), and occasional eddies splitting off from the Gulf Stream.

The waters of this region are known as "slope waters" and are found between the warm saline inner edge of the Gulf Stream and the cooler less saline shelf waters (Stommel, 1966). An examination of the vertical thermal structure shows inversions and the presence of different waters at different depths.

Bioenvironmental Relationships

Contour configurations plotted from Bongo net data follow those of the temperature field in a number of cases. Neuston contours more closely approximate the surface σ_t configuration. A detailed interpretation of any oceanographic relationships will require an analysis of the physio-chemical environmental data, integrated over the depth of tow for each station.

Although certain of the data (satellite; current velocity sections; and temperature, salinity, and density distributions) indicate areas of surface and subsurface shear, or even eddies, the establishment of ecological relationships for such a complex area goes beyond the purpose of this paper, which is to give a complete as possible description of the biological features observed during the survey.

Displacement Volumes. A wide range of volumes were encountered throughout the sampling area and were influenced in part by organisms such as siphonophores and salps with large volume bodies. A general distribution pattern was evident. Displacement volumes ranged from 0.06 to 0.09 ml/m³ for Bongo samples (for both the 333 μ -mesh and 505 μ -mesh nets) in waters that appeared to be oceanic in origin, and less than 0.01 ml/m³ for neuston samples. Shelf waters yielded higher displacement volumes, ranging from 0.24 to 0.29 ml/m³ for 333 μ , 0.11 to 0.25 ml/m³ for 505 μ , and 0.02 to 0.09 ml/m² for neuston 947 μ .

Dry Weights. The distribution of dry weights exhibited a far less patchy pattern as the high volumes caused by the presence of siphonophore and salps were minimized (figs. 37, 38, 39, and table 3). Note that the unit gm/1000 m² or m³ is used in the table, but the unit mg/m² or m³ is used in the figures. Since the conversion factor for these units is "1," the numerical values are identical. For the Bongo samples, the southeast corner is separated from the remainder of the survey area by a band of relatively low values for dry weight. This may be a result of the warm subsurface layer discussed by Warsh (1974). The distribution of neuston dry weights showed a pattern that followed the inferred currents (fig. 40).

Fish Eggs

Table 4 shows the standing crop, percent standing crop and measurements for all samples of fish eggs. The majority of the identifiable fish eggs were taken inside the 200-m isobath (figs. 2, 3, 4). Ranked in abundance were Scomber scomberus, Urophycis sp., Merluccius sp., Brosme brosme, Brevoortia tyrannus and Paralichthys oblongus. Only Urophycis could be identified from any offshore stations.

Scomber eggs were only found in abundance at Station 1, but their standing crops at this one station caused them to outrank all other species.

The distribution of Urophycis eggs is shown in figure 5. Their abundance coincided with the boreal plankton assemblages. The distribution of Merluccius (probably bilinearis) eggs (fig. 6) was similar to that of Urophycis. Eggs of Brosme were principally found in the cooler low salinity waters in the northern quadrant of the survey area (fig. 7). Brevoortia and Paralichthys eggs were only found in shelf waters (figs. 8 and 9).

Two distinct groups of unidentifiable eggs were found. One group ("Unknown No. 6", table 4) was found to the north and offshore (Stations 10, 11, 12, and 23) and the second ("Unknown No. 4") was found offshore (Stations 9, 10, 15, 16, and 17). Both of these unknowns, along with most of the other unidentified eggs were found at the eastern stations. Most had a vesicular yolk, a characteristic of Anguilliform, Clupeiform and Salmoniform fish eggs; several bathypelagic groups are also characterized this way. Some have been tentatively identified as Gonostomatidae. One egg, with distinctive chorional sculpturing, was identified as a macrourid egg. Other species of eggs identified but usually represented by singular occurrences are, Lophius americanus, Prionotus evolans, Glyptocephalus cynoglossus, Tautoglabrus adspersus, Limanda ferruginea and Melanogrammus aeglefinus.

The greatest diversity of identifiable eggs, all shelf species, was found at Stations 21 and 22.

Larvae and Juvenile Fish

Tables 5 and 6 contain the standing crop, biomass, and lengths of all fish and fish larvae taken. Over 50 identifiable species, most of tropical origin, were taken in the neuston samples. An almost equal number were identified from the bongo tows. Except for 20 unknowns the remainder were identified to family. The species with highest standing crops were shelf spawning populations (Pomatomus saltatrix and Urophycis sp.). Diversity was greatest offshore to the southeast where temperatures and salinity were higher. Figures 10, 11, 12, and 13 depict the distribution of Urophycis, Pomatomus saltatrix, Mugil and Tetradontidae post larvae or juveniles (see lengths in table 5). The relationships of their position to the inferred surface currents (fig. 40) suggests that they are all from southern stocks.

The standing crop and percent standing crop of tropical fish are shown in Figures 14 and 15. Their distribution may be used to infer waters of tropical origin (percent standing crop $\geq$ 75%).

Adult myctophids were only found in the most oceanic neuston samples (fig. 16) (stations 17-19). The larvae on the other hand were found throughout the area (fig. 17). They were least abundant at the stations where the shelf species were most common.

The neuston samples were dominated by juvenile shelf and inshore spawning species (Pomatomus saltatrix, Urophycis sp., Mugil sp., Monacanthus hispidus and Tetradontidae). The two dominant groups in the bongo samples, however, were larval myctophids and bothids.

Invertebrate Zooplankton

Major Taxa. Standing crops and percent standing crops for the 17 major taxa sorted are found in tables 7 and 8. Copepods are reported separately in table 9.

Chaetognaths. Chaetognaths were most abundant over the shelf (333 μ -net: >40,000/1000 m³; 505 μ -net: > 23,000/1000 m³) and least abundant in slope waters (505 μ - and 333 μ -nets: < 10,000/1000 m³).

Pteropods. Pteropods were most abundant in the shelf samples (Stations 1, 3, 5, and 21) (table 10). Speciation of 333 μ -net specimens was difficult as there were so many juvenile Limacina sp. A boreal combination of Limacina retroversa, L. helicina, and juvenile Limacina sp. (probably L. retroversa) was found at stations 3, 9, 10, 21, and 23. Subtropical species were found, and dominated at stations 6, 7, 8, and 19; these included Limacina trochiformis, L. inflata, Cresis virgula conica, Cavolina spp., Clio spp. and Diacria trispinosa. Both the "boreal" and "subtropical" species listed above were found at stations 8, 10, 18, and 19. Their relative percentages suggested a boreal predominance through the area except at stations 8, 10, and 18 where the water is of Gulf Stream origin.

The two assemblages were found in the 505 μ -nets also in roughly the same percentages, although there were more in the 505 μ -nets. The neuston net took only the larger subtropical species such as the Cavolina spp.

Figures 18 and 19 show the standing crop and percent standing crop of L. retroversa, a boreal and the dominant species. In the region where it exceeds 75 percent, the water column is principally boreal. Percentage values of 100 are shelf water. Figure 20 depicts the combined percentages of subtropical indicator species Cresis, Cavolina, Clio, Diacris and some Limacina (Austin, 1971). These occurrences correspond to the presence of a warm water layer between 50 and 350 m which is discussed further by Warsh (1974).

Heteropods. Heteropods were generally more abundant in the 333 μ -net samples, probably due to their size. The dominant genus was Atlanta. It was most abundant at stations 7, 8, 14, 16, and 22. A high standing crop of this genus was also found in the neuston sample at Station 3.

Cephalopods. Both Decapoda and Octopoda larvae were collected (Table 11). Octopod larvae were collected by the Bongo nets and the neuston net in standing crops of 1.7 to 3.1/1000 m³ and 0.8/1000 m², respectively. They were only taken at "oceanic stations". Squid larvae were more widely distributed but Bongo net standing crops never exceeded 6.2/1000 m³ (Station 3). They were predominantly taken from oceanic water. Exceptions were three individuals taken at Stations 1 (neuston net) and 3 (Bongo nets).

Cladocerans. Due to their size no cladocerans were captured by the neuston net although they are known to inhabit the neuston layer (Gieskes, 1970). Cladocerans were only taken in any abundance (500/1000 m³) at continental shelf Stations 1 and 5.

They were not collected at Station 3 but were abundant at Stations 22 and 23 (208-345/1000 m³). Their distribution in the 505 samples (Fig. 21) suggests that they are good indicators of shelf water. Their presence in the samples at Stations 22 and 23 would seem to indicate the presence of shelf waters farther offshore in this area.

Euphausiids. Both Boreal-Arctic and Subtropical euphausiids were collected (table 12 and fig. 22). The dominant species Nyctiphanes couchii is cold-temperate or Boreal (Raymont, 1963) and was often the only species identified at some stations. It was collected in greatest numbers at Stations 3 and 5. Species of the genera Euphausia and Stylocheiron which are Subtropical (James, 1970) were also collected, as was the Tropical species Thysanopoda aequalis. These species predominated at Stations 2, 6, 10, 18, and 22. At most stations, however, combinations of Nyctiphanes and Stylocheiron were collected illustrating the heterogeneity of the water column.

Crustacean Larvae. Larvae were sorted as caridian or brachyuran. Brachyuran larvae predominated in the cooler waters on the shelf (Stations 1 and 21) (fig. 23) and caridian larvae offshore (Stations 16-18) (fig. 24).

Copepods. The copepods were the dominant taxa collected. The most common genera taken in the 333 μ -net were Centropages, Calanus, Oithona, Euaugaptilus, Rhincalanus, and Pleuromamma. Total standing crops were generally high averaging over 100,000/1000 m³ (fig. 25). Centropages spp. (probably typicus) was the most abundant copepod over the shelf (fig. 26) where standing crops exceeded 50,000/1000 m³ and it comprised over 30 percent of the population. It was also relatively abundant (50%) at the southern stations in the sampling area. At Station 14 the temperature and salinity relationships at 20 to 30 m were similar to those at the surface on the shelf and may explain the presence of Centropages offshore. Its absence at Stations 11 and 12 will be explained later. Calanus, one of the major pelagic forage organisms was most abundant (10,000/1000 m³) at stations over the shelf (fig. 27). At the offshore stations it was least abundant (<5,000/1000 m³) where the water column exhibited more stability, suggesting a more oceanic origin.

Two deep (400-900m) Gulf Stream copepods (Oncaea and Euaugaptilus) (Owre and Foyo, 1967) were found in the study area (figs. 28 and 29). Both were found inside the 200-m isobath suggesting the presence of deeper mainstream Gulf Stream waters.

The same genera predominated in the 505 μ -nets as in the 333 μ -net, with greatest abundance being found on the shelf (predominantly Calanus and Rhincalanus) (fig. 30). Centropages and Calanus distribution patterns were similar to the 333 μ -net patterns (figs. 31 and 32). A noticeable departure however, was their paucity at Stations 11 and 12. At these two stations Rhincalanus, Euaugaptilus, Oithona (probably plumifera) and Pleuromamma predominated which strongly indicates the presence of Gulf Stream water.

Euchirella rostrata is reported to be a deeper water species of the northwestern Atlantic (Wilson, 1932), never common when found (Owre and Foyo, 1967). It was present at all DWDS stations sampled and was relatively

more abundant at Stations 18 and 19, and in a NE-SW band through the center of the survey area (fig. 33). It was not common at Stations 11 and 12 where the deeper Gulf Stream components were collected. A similar band for Rhincalanus coronatus was observed (fig. 34), but high values also occurred onshore and offshore. Grice and Hart (1962) found both species in slope waters at the shelf edge.

Adult copepod species diversity was calculated for both the 333 and 505 μ -nets utilizing Simpson's index, λ . The index is derived from the expression

$$\lambda = \sum_{i=1}^k \left(\frac{n_i}{N} \right)^2$$

where n_i = number of individuals in the i th species,
 N = total number of individuals,
 k = number of species.

Contour configurations for the index (figs. 35 and 36) indicate a differentiation of shelf waters from those of the slope waters. Lower diversity due to the high standing crop and lower number of species are to be expected in light of the boreal faunal composition. The higher values of the slope water are the result of a mixing of subtropical and boreal assemblages. Lower values at the deeper stations may be due to the presence of shelf plankton (Station 14) or deeper Gulf Stream (Stations 11 and 12) components.

SUMMARY

The upper 100 m of Deepwater Dumpsite 106 off New York Bight is one of rapid spatial and temporal oceanographic variation. The slope water, located between the cool lower-salinity Atlantic Bight shelf water and the warm saline Gulf Stream, is in a region of temperature inversions and advective mixing. It is a region of biological transition from a predominantly boreal shelf fauna (in May) to that of a subtropical Gulf Stream fauna. Lenses of either fauna may be found within the other water mass. In many regions along the 200-m isobath the two faunae appear evenly mixed, suggesting upstream mixing.

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Table 1.--MARMAP station activities summary for Albatross IV cruise
74-5, May 10-23, 1974

Sta- tion	Day May 1974	Position		Type* of n e t	Start time	Dura- tion	Max. depth
		Lat. N	Long. W				
		° ' "	° ' "		GMT	min:s	m
1	10	35 00	73 00	Neuston	0405	11:00	S**
				Bongo 333	0440	7:44	86
				Bongo 505	0440	7:44	86
2	11	38 51	72 44	Neuston	2230	10:00	S
				Bongo 333	2252	26:20	187
				Bongo 505	2252	26:20	187
3	12	38 36	73 21	Bongo 333	0850	7:43	65
				Bongo 505	0850	7:43	65
				Neuston	0908	10:00	S
4	13	38 40	73 00	Neuston	2205	10:00	S
				Bongo 333	2238	22:10	247
				Bongo 505	2238	22:10	247
5	16	38 10	72 45	Neuston	0132	10:00	S
				Bongo 333	0153	9:58	97
				Bongo 505	0153	9:58	97
6	16	39 00	72 30	Neuston	0834	5:00	S
				Bongo 333	0849	21:37	245
				Bongo 505	0849	21:37	245
7	16	38 56	72 22	Bongo 333	1443	23:00	197
				Bongo 505	1443	23:00	197
				Neuston	1508	10:00	S
8	16	38 51	72 15	Neuston	2333	10:00	S
				Bongo 333	2351	21:36	255
				Bongo 505	2351	21:36	255
9	17	38 43	72 09	Bongo 333	1140	21:17	235
				Bongo 505	1140	21:17	235
				Neuston	1210	10:00	S
10	17	38 40	72 00	Neuston	2257	10:00	S
				Bongo 333	2313	20:14	237
				Bongo 505	2313	20:14	237
11	18	39 00	71 59	Bongo 333	1405	21:45	235
				Bongo 505	1405	21:45	235
				Neuston	1435	10:00	S
12	18	38 55	72 07	Neuston	2304	10:00	S
				Bongo 333	2320	26:00	215
				Bongo 505	2320	26:00	215
13	19	38 45	72 22	Bongo 333	1225	20:32	225
				Bongo 505	1225	20:32	225
				Neuston	1250	10:00	S
14	19	38 40	72 31	Neuston	2235	10:00	S
				Bongo 333	2250	20:00	235
				Bongo 505	2250	20:00	235

Table 1.--MARMAP station activities summary for Albatross IV cruise
74-5, May 10-23, 1974 (continued)

Sta- tion	Day May 1974	Position		Type* of n e t	Start time	Dura- tion	Max. depth
		Lat. N	Long. W				
		° ' "	° ' "		GMT	min:s	m
15	20	38 30	72 15	Bongo 333	1144	20:19	197
				Bongo 505	1144	20:19	197
				Neuston	1208	10:00	S
16	20	38 20	71 58	Neuston	2107	10:00	S
				Bongo 333	2130	20:06	187
				Bongo 505	2130	20:06	187
17	21	38 20	71 44	Bongo 333	0637	20:16	165
				Bongo 505	0637	20:16	165
18	21	38 40	71 30	Neuston	1653	10:00	S
				Bongo 333	1714	20:01	85
				Bongo 505	1714	20:01	85
19	22	38 50	71 45	Bongo 333	0512	20:51	177
				Bongo 505	0512	20:51	177
				Neuston	0537	10:00	S
20	22	39 10	72 15	Neuston	1719	10:00	S
				Bongo 333	1737	20:05	141
				Bongo 505	1737	20:05	141
21	22	39 20	72 31	Bongo 333	2350	10:55	138
				Bongo 505	2350	10:55	138
				Neuston	0005	10:00	S
20	23	39 20	72 04	Neuston	0810	***	S
				Bongo 333	0826	21:43	183
				Bongo 505	0826	21:43	183
23	23	39 10	71 46	Bongo 333	1615	20:12	160
				Bongo 505	1615	20:12	160
				Neuston	1643	10:00	S

* Zooplankton net sizes, expressed as "mouth dimension/mesh size" are:
Neuston--1.0 m height by 2.0 m width/947 μ ; Bongo--61 cm diameter/333 μ and
505 μ .

** S = surface.

*** Data not available.

Table 2.--Aliquot sizes examined of water volumes filtered, and standard haul factors, Albatross IV 74-5 zooplankton samples at Deepwater Dumpsite 106

Station	NEUSTON			BONGO				
	9 4 7		Area Filt. (m ²)	3 3 3		Aliquot	5 0 5	
	Aliquot			Volume Filt. (m ³)	Standard Haul Factor		Volume Filt. (m ³)	Standard Haul Factor
001	1/16		3148.4	1/16	192.6	1/8	191.3	22.2
002	1/32		2444.6	1/16	375.7	1/8	363.1	19.4
003	1/32		3086.7	1/16	166.1	1/4	161.0	24.8
004	1/16		3259.5	1/16	326.6	1/16	358.3	14.5
005	1/64		1222.3	1/16	155.4	1/8	225.1	23.2
006	1/16		2259.4	1/16	349.7	1/16	337.5	13.8
007	1/32		3407.7	1/16	364.7	1/8	400.1	20.3
008	1/128		2926.2	1/16	334.0	1/16	319.5	12.5
009	1/8		3667.0	1/8	389.4	1/8	369.2	15.7
010	1/32		2741.0	1/16	347.9	1/16	329.3	13.9
011	1/8		3037.3	1/8	341.6	1/8	267.8	11.4
012	1/8		2815.0	1/8	283.8	1/8	271.1	12.6
013	1/8		2815.0	1/16	304.3	1/8	292.0	13.0
014	1/8		3037.3	1/32	367.3	1/32	354.8	15.1

Table 2 (continued)

NEUSTON				BONGO			
Station	9 4 7		Area Filt. (m ²)	3 3 3		5 0 5	
	Aliquot	Filt. (m ²)		Aliquot	Volume Filt. (m ³)	Aliquot	Volume Filt. (m ³)
							Standard Haul Factor
015	1/8	3370.6		1/8	340.1	1/8	328.3
016	1/8	2666.9		1/16	435.8	1/16	414.4
017	1/16	3111.4		1/16	358.3	1/16	356.2
018	1/8	3296.6		1/32	585.5	1/64	593.3
019	1/32	2778.0		1/64	615.5	1/64	693.1
020	1/8	4037.4		1/8	523.8	1/8	507.9
021	1/16	3086.7		1/32	240.9	1/16	228.2
022	1/8	*3086.7		1/16	512.6	1/8	499.3
023	1/8	2518.7		1/16	551.6	1/8	539.1
							16.7
							22.2
							21.6
							69.8
							39.2
							36.0
							16.5
							27.3
							33.7

*No time given--10 minutes at 5 knots was assumed in formula.

Table 3.--Displacement volumes and dry weights, Albatross IV
cruise 74-5 zooplankton samples at Deepwater Dumpsite 106

NEUSTON 947

Station	Displacement Volume (ml)	Biomass-Displacement (ml/1000 m ²) ³	Dry Weight (gm/1000m ²) ³
001	25	8	.654
002	88	36	5.276
003	94	30	3.889
004	32	10	.903
005	112	92	13.322
006	44	19	.839
007	12	4	3.578
008	829	283	3.047
009	15	4	.496
010	43	16	3.029
011	10	3	.407
012	10	4	.656
013	5	2	.182
014	17	6	.591
015	11	3	.253
016	13	5	.557
017	52	17	1.678
018	12	4	.359
019	82	30	3.019
020	7	2	.365
021	65	21	2.813
022	21	7	1.032
023	30	12	.719

Table 3 (continued)

BONGO 505

<u>Station</u>	<u>Displacement Volume (ml)</u>	<u>Biomass Displacement (ml/1000 m²)³</u>	<u>Dry Weight (gm/1000m²)³</u>
001	46	240	11.912
002	24	66	5.102
003	18	112	16.058
004	34	95	6.399
005	35	156	17.021
006	60	178	10.512
007	48	120	7.716
008	55	172	11.756
009	32	87	4.418
010	41	124	9.328
011	18	67	6.621
012	26	96	6.316
013	22	76	5.567
014	55	155	15.027
015	16	49	4.927
016	94	227	10.967
017	50	140	11.464
018	95	160	8.669
019	211	304	3.376
020	30	59	4.928
021	56	245	23.436
022	38	76	7.014
023	28	52	4.809

Table 3 (continued)

BONGO 333

Station	Displacement Volume (ml)	Biomass-Displacement (ml/1000 m ²) ³	Dry Weight (gm/1000m ²) ³
001	no sample		
002	35	93	6.805
003	40	240	19.114
004	30	91	7.952
005	45	290	25.343
006	59	169	12.934
007	48	132	12.199
008	30	90	11.334
009	33	85	6.152
010	50	144	9.120
011	28	81	5.824
012	25	88	5.326
013	34	111	7.478
014	60	163	11.569
015	31	91	5.849
016	53	122	7.423
017	71	198	15.941
018	117	200	12.707
019	224	364	38.970
020	30	57	3.946
021	68	282	30.360
022	56	109	10.328
023	36	65	4.539

Table 4.--Fish egg standing crops, percent standing crops, and measurements,
Albatross IV cruise 74-5, Deepwater Dumpsite 106

NEUSTON 947	Number	Standing Crop (No./1000m ²)	Percent Standing Crop	Diameter (mm)	
				Range	Mean $\pm$ S.D.
Station 1-1					
<i>Scomber scombrus</i>	3187	1012	100.0	1.12-1.33	(n=640) 1.21 $\pm$.03
Total	3187	1012	100.0		
Station 2-1					
<i>Scomber scombrus</i>	1	less than 1	100.0	1.26	1.26
Total	1	less than 1	100.0		
Station 3-1					
<i>Brevoortia tyrannus</i>	6	2	66.7	1.42-1.53	1.48 $\pm$.04
<i>Lophius americanus</i>	1	less than 1	11.1	1.41	----
<i>Erosme brasme</i>	1	less than 1	11.1	1.34	----
Unknown 15	1	less than 1	11.1	2.32	----
Total	9	3	100.0		
Station 4-1					
<i>Scomber scombrus</i>	1	less than 1	50.0	----	----
Unknown 15	1	less than 1	50.0	2.47	----
Total	2	less than 1	100.0		
Station 5-1					
<i>Brevoortia tyrannus</i>	3	2	22.2	1.40-1.59	1.50 $\pm$.10
<i>Scomber scombrus</i>	7	6	66.7	1.11-1.22	1.17 $\pm$.03
<i>Paralichthys oblongus</i>	1	less than 1	3.7	1.05	----
Unknown 3 (<i>Prionotus evolans</i>)	1	less than 1	3.7	1.24	----
Unknown 15	1	less than 1	3.7	2.31	----
Total	13	9	100.0		
Station 6-1					
Unknown 3 (<i>Prionotus evolans</i>)	1	less than 1	50.0	1.24	----
Unknown 15	1	less than 1	50.0	2.10	----
Total	2	less than 1	100.0		

Table 4 (continued)

NEUSTON 947 Station 7-1 } Station 8-1 } Station 9-1 }	Number	Standing Crop (No./1000m ²)	Percent Standing Crop	Diameter (mm)	
				Range	Mean $\pm$ S.D.
Station 10-1 <i>Lophius americanus</i> Total	2 2	less than 1 less than 1	100.0 100.0	1.43-1.54	---
Station 11-1 Unknown 6	2	less than 1			
Unknown 22	1	less than 1	50.0	.95	---
Unknown 23	1	less than 1	25.0	2.54	---
Total	4	less than 1	25.0	1.21	---
Station 12-1 <i>Esox blosme</i>	2	less than 1			
<i>Scorpaenopsis</i>	2	less than 1	40.0	1.37-1.40	---
Unknown 15	1	less than 1	40.0	1.25-1.26	---
Total	5	less than 1	20.0	2.40	---
Station 13-1 Unknown 15	1	less than 1	100.0		
Total	1	less than 1	100.0	2.30	---
Station 14-1 Unknown 23	1	less than 1			
Total	1	less than 1	100.0	1.21	---
Station 15-1 no eggs taken					
Station 16-1 Macrouridae	1	less than 1	50.0		
<i>Scorpaenopsis</i>	1	less than 1	50.0	1.26	---
Total	2	less than 1	100.0	1.32	---

Table 4 (continued)

NEUSTON 947		Number	Standing Crop (No./1000m ²)	Percent Standing Crop	Range	Mean $\pm$ S.D.
Station 17-1						
Lophius americanus		1	less than 1	50.0	1.55	----
Scomber scombrus		1	less than 1	50.0	1.28	----
Total		2	1	100.0		
Station 18-1						
Lophius americanus		2	1	66.7	1.55-1.56	----
Unknown 15		1	less than 1	33.3	2.52	
Total		3	1	100.0		
Station 19-1		no eggs taken				
Station 20-1						
Lophius americanus		1	less than 1	1.9	1.56	----
Brosme brosme		50	12	98.1	1.31-1.47	1.38 $\pm$.03
Total		51	12	100.0		
Station 21-1						
Brosme brosme		113	34	97.1	1.14-1.19	----
Scomber scombrus		2	1	2.9	1.32-1.45	1.38 $\pm$.02
Total		115	35	100.0		
Station 22-1						
Brevoortia tyrannus		98	32	9.0	1.38-1.79	1.59 $\pm$.07
Brosme brosme		957	310	87.3	1.28-1.44	(n=400) 1.38 $\pm$.02
Scomber scombrus		2	1	0.2	1.12-1.13	----
Glyptocephalus cynoglossus		1	less than 1	0.1	1.21	----
Unknown 24		37	12	3.4	1.63-1.78	1.72 $\pm$.04
Total		1095	355	100.0		
Station 23-1						
Lophius americanus		4	2	40.0	1.40-1.47	1.44 $\pm$.03
Brosme brosme		5	2	50.0	1.33-1.39	1.37 $\pm$.02
Damaged		1	less than 1	10.0	----	----
Total		10	4	100.0		

Table 4 (continued)

BONGO 505

	Number	Standing Crop (No./1000m ³)	Percent Standing Crop	Diameter (mm)	
				Range	Mean $\pm$ S.D.
Station 1-1					
<i>Merluccius bilinearis</i>	38	199	13.3	1.01-0.92	.96 $\pm$.02
<i>Urophycis</i> sp.	1	5	0.3	0.79	----
<i>Scomber scombrus</i>	246	1286	86.4	1.12-1.40	1.20 $\pm$.14
Total	285	1490	100.0		
Station 2-1					
<i>Urophycis</i> sp.	4	11	55.0	0.77-0.79	.78 $\pm$.01
Unknown 1	1	3	15.0	0.91	----
Unknown 2	1	3	15.0	0.71	----
Damaged	1	3	15.0	----	----
Total	7	20	100.0		
Station 3-1					
<i>Brevoortia tyrannus</i>	1	6	13.9	1.60	----
<i>Merluccius bilinearis</i>	1	6	13.9	0.95	----
<i>Paralichthys oblongus</i>	1	6	13.9	1.09	----
Unknown 3 (<i>Prionotus evolans</i> ?)	3	19	44.4	1.18-1.23	1.21 $\pm$.03
Damaged	1	6	13.9	----	----
Total	7	43	100.0		
Station 4-1					
<i>Stosme broasme</i>	4	11	64.7	1.39-1.44	1.42 $\pm$.02
<i>Urophycis</i> sp.	2	6	35.3	0.75-0.76	----
Total	6	17	100.0		
Station 5-1					
<i>Brevoortia tyrannus</i>	12	53	16.5	1.50-1.60	1.55 $\pm$.03
<i>Merluccius bilinearis</i>	11	49	15.3	0.85-0.97	.88 $\pm$.04
<i>Urophycis</i> sp.	34	151	47.3	0.73-0.86	.79 $\pm$.03
<i>Scomber scombrus</i>	2	9	2.8	1.06	----
<i>Paralichthys oblongus</i>	13	58	18.1	0.97-1.06	1.02 $\pm$.03
Total	72	320	100.0		

Table 4 (continued)

BONGO 505		Number	Standing Crop (No./1000m ³)	Percent Standing Crop	Diameter (mm)	
					Range	Mean $\pm$ S.D.
Station 6-1						
<i>Urophycis</i> sp.		1	3	33.4	0.75	---
Unknown 1		1	3	33.3	1.04	---
Unknown 4		1	3	33.3	0.80	---
Total		3	9	100.0		
Station 7-1						
<i>Urophycis</i> sp.		1	2	33.4	0.77	---
<i>Scomber scombrus</i>		1	2	33.3	1.30	---
Unknown 4		1	2	33.3	0.75	---
Total		3	6	100.0		
Station 8-1						
<i>Urophycis</i> sp.		3	9	75.0	0.75-0.77	.76 $\pm$.01
<i>Scomber scombrus</i>		1	3	25.0	1.28	---
Total		4	12	100.0		
Station 9-1						
<i>Urophycis</i> sp.		1	3	50.0	0.79	---
Unknown 1		1	3	50.0	0.87	---
Total		2	6	100.0		
Station 10-1						
<i>Merluccius bilinearis</i>		1	3	14.3	0.93	---
<i>Urophycis</i> sp.		3	9	42.8	0.74-0.78	.76 $\pm$.04
Unknown 5		1	3	14.3	0.65	---
Damaged		2	6	28.6	---	---
Total		7	21	100.0		
Station 11-1						
<i>Urophycis</i> sp.		2	7	11.8	0.74-0.76	.75
<i>Tautoglabrus adspersus</i>		1	4	6.9	0.73	---
<i>Glyptocephalus cynoglossus</i>		2	7	11.8	1.14-1.16	1.15
Unknown		11	41	69.5	0.93-0.97	.95 $\pm$.04
Total		16	59	100.0		

Table 4 (continued)

	Number	Standing Crop (No./1000m ³)	Percent Standing Crop	Diameter (mm).	
				Range	Mean $\pm$ S.D.
BONGO 505					
Station 12-1					
<i>Merluccius bilinearis</i>	3	11	38.0	0.92-0.96	.94 $\pm$.02
<i>Urophycis</i> sp.	2	7	24.1	0.81-0.82	----
<i>Scomber scombrus</i>	1	4	13.8	1.18	----
Unknown 6	2	7	24.1	0.97-0.98	----
Total	8	29	100.0		
Station 13-1					
Unknown 4	1	3	33.3	0.77	----
Unknown 6	1	3	33.3	0.92	----
Unknown 7	1	3	33.4	0.79	----
Total	3	9	100.0		
Station 14-1					
<i>Urophycis</i> sp.	3	8	100.0	0.76-0.77	----
Total	3	8	100.0		
Station 15-1					
Unknown 4	1	3	100.0	0.76	----
Total	1	3	100.0		
Station 16-1					
<i>Urophycis</i> sp.	2	5	50.0	0.78-0.79	----
Damaged	2	5	50.0	----	----
Total	4	10	100.0		
Station 17-1					
<i>Urophycis</i> sp.	2	6	40.0	0.75-0.78	----
Unknown 6	1	3	20.0	0.91	----
Unknown 8	1	3	20.0	0.93	----
Damaged	1	3	20.0	----	----
Total	5	15	100.0		

Table 4 (continued)

BONGO 505	Number	Standing Crop (No./1000m ³)	Percent Standing Crop	Diameter (mm)	
				Range	Mean $\pm$ S.D.
Station 18-1					
<i>Urophycis</i> sp.	1	2	100.0		----
Total	1	2	100.0	0.79	
Station 19-1					
<i>Urophycis</i> sp.	2	3	42.9	0.78-0.81	----
Unknown 6	3	4	57.1	0.87-0.97	.92 $\pm$.05
Total	5	7	100.0		
Station 20-1					
<i>Brosme brosme</i>	7	14	13.6	1.35-1.42	1.39 $\pm$.03
<i>Merluccius bilinearis</i>	1	2	1.9	0.95	----
<i>Urophycis</i> sp.	29	57	55.4	0.73-0.83	.77 $\pm$.03
<i>Paralichthys oblongus</i>	5	10	9.7	0.97-1.04	1.00 $\pm$.03
Unknown 4	4	8	7.8	0.73-0.80	.77 $\pm$.03
Unknown 6	3	6	5.8	0.92	----
Unknown 9	1	2	1.9	0.73	----
Unknown 10	2	4	3.9	0.73	----
Total	52	103	100.0		
Station 21-1					
<i>Erevoortia tyrannus</i>	15	66	16.6	1.52-1.68	1.62 $\pm$.07
<i>Brosme brosme</i>	9	39	9.8	1.36-1.46	1.39 $\pm$.04
<i>Melanogrammus aeglefinus</i>	2	9	2.3	1.39-1.43	----
<i>Merluccius bilinearis</i>	47	206	51.7	0.92-1.02	.96 $\pm$.02
<i>Urophycis</i> sp.	12	53	13.3	0.72-0.82	.78 $\pm$.04
<i>Paralichthys oblongus</i>	3	13	3.3	1.02-1.03	1.02
Unknown 11	1	4	1.0	1.73	----
Unknown 12	1	4	1.0	1.02	----
Damaged	1	4	1.0	----	----
Total	91	398	100.0		

Table 4 (continued)

BONGO 505

Station 22-1

	Number	Standing Crop (No./1000m ³)	Percent Standing Crop	Diameter (mm) Range	Mean $\pm$ S.D.
<i>Brevoortia tyrannus</i>	7	14	24.2	1.53-1.64	1.59 $\pm$.05
<i>Brosme brosme</i>	5	10	17.2	1.36-1.42	1.39 $\pm$.03
<i>Merluccius bilinearis</i>	4	8	13.9	0.89-0.98	.94 $\pm$.04
<i>Urophycis</i> sp.	4	8	13.9	0.76-0.83	.78 $\pm$.04
<i>Paralichthys oblongus</i>	3	6	10.3	0.98-0.99	.98 $\pm$ -
<i>Limanda ferruginea</i>	1	2	3.4	0.89	----
Unknown 16	1	2	3.4	0.91	----
Unknown 13	1	2	3.4	1.08	----
Unknown 14	1	2	3.4	0.85	----
Damaged	2	4	6.9	----	----
Total	29	58	100.0		

Station 23-1

<i>Merluccius bilinearis</i>	7	13	39.4	0.89-0.98	.94 $\pm$.03
<i>Urophycis</i> sp.	3	6	18.2	0.76-0.82	.79 $\pm$.03
<i>Paralichthys oblongus</i>	3	6	18.2	0.92-0.98	.95 $\pm$.03
Unknown 6	2	4	12.1	0.93-0.95	----
Damaged	2	4	12.1	----	----
Total	17	33	100.0		

Table 4 (continued)

BONGO 333	Number Taken	Standing Crop (No./1000m ³)	Percent Standing Crop	Diameter (mm)	
				Range	Mean $\pm$ S.D.
Station 1-1 No Sample Taken					
Station 2-1					
<i>Urophycis</i> sp.	4	11	78.6	0.75-0.79	.77 $\pm$.02
Unknown 15	1	3	21.4	2.32	----
Total	5	14	100.0		
Station 3-1					
<i>Brevoortia tyrannus</i>	1	6	20.0	1.53	----
<i>Merluccius bilinearis</i>	3	18	60.0	0.93-0.96	.95 $\pm$.05
<i>Paralichthys oblongus</i>	1	6	20.0	1.06	----
Total	5	30	100.0		
Station 4-1					
<i>Tautogolabrus adspersus</i>	1	3	20.0	0.70	----
Unknown 1	2	6	40.0	0.90-0.94	----
Unknown 6	2	6	40.0	0.96-0.97	----
Total	5	15	100.0		
Station 5-1					
<i>Brevoortia tyrannus</i>	2	13	2.8	1.55-1.62	----
<i>Merluccius bilinearis</i>	13	84	18.1	0.90-1.00	.95 $\pm$.02
<i>Urophycis</i> sp.	44	283	61.1	0.73-0.87	.81 $\pm$.03
<i>Scorpaenopsis</i>	1	6	1.3	1.12	----
<i>Paralichthys oblongus</i>	12	77	16.7	0.99-1.07	1.03 $\pm$.02
Total	72	463	100.0		
Station 6-1					
<i>Urophycis</i> sp.	3	9	100.0	0.75-0.87	----
Total	3	9	100.0		
Station 7-1					
<i>Urophycis</i> sp.	1	3	50.0	0.77	----
<i>Tautogolabrus adspersus</i>	1	3	50.0	0.72	----
Total	2	6	100.0		

Table 4 (continued)

Table 4 (continued)

	Number	Standing Crop (No./1000m ³)	Percent Standing Crop	Diameter (mm) Range	Mean $\pm$ S.D.
BONGO 333					
Station 8-1	1	3	100.0	0.93	---
Unknown 6	1	3	100.0		
Total					
Station 9-1	1	3	100.0	0.79	---
<i>Urophycis</i> sp.	1	3	100.0		
Total					
Station 10-1	1	3	13.0	0.88	---
Unknown 1	5	14	60.9	0.73-0.76	.75 $\pm$.01
Unknown 4	2	6	26.1	0.91-0.95	---
Unknown 6	8	23	100.0		
Total					
Station 11-1	1	3	9.4	---	---
<i>Urophycis</i> sp.	1	3	9.4	0.76	---
Unknown 4	8	23	71.8	0.92-0.96	.94 $\pm$.01
Unknown 6	1	3	9.4	0.87	---
Unknown 16	11	32	100.0		
Total					
Station 12-1	1	4	9.3	0.96	---
<i>Merluccius bilinearis</i>	1	4	9.3	0.81	---
<i>Urophycis</i> sp.	2	7	16.2	0.77-0.78	---
Unknown 4	8	28	65.2	0.90-1.00	.95 $\pm$.04
Unknown 6	12	43	100.0		
Total					
Station 13-1	1	3	13.6	0.74	---
<i>Urophycis</i> sp.	4	13	59.2	0.74-0.77	.76 $\pm$.02
Unknown 4	1	3	13.6	0.92	---
Unknown 6	1	3	13.6	0.76	---
Unknown 17	7	22	100.0		
Total					

Table 4 (continued)

BONGO 333	Number	Standing Crop (No./1000m ³)	Percent Standing Crop	Diameter (mm)	
				Range	Mean $\pm$ S.D.
Station 14-1					
<i>Urophycis</i> sp.	2	5	100.0	0.76-0.78	---
Total	2	5	100.0		
Station 15-1					
<i>Urophycis</i> sp.	2	6	28.6	0.60-0.74	---
Unknown 1	1	3	14.3	0.87	---
Unknown 4	4	12	57.1	0.74-0.78	.76 $\pm$.04
Total	7	21	100.0		
Station 16-1					
<i>Urophycis</i> sp.	1	2	18.2	0.74	---
<i>Tautoglabrus adspersus</i>	1	2	18.2	0.70	---
Unknown 4	3	7	63.6	0.76	.76
Total	5	11	100.0		
Station 17-1					
Unknown 4	6	17	74.0	0.74-0.78	.77 $\pm$.02
Unknown 14	1	3	13.0	0.82	---
Unknown 13	1	3	13.0	0.82	---
Total	8	23	100.0		
Station 18-1					
<i>Urophycis</i> sp.	1	2	50.0	0.79	---
Unknown 19	1	2	50.0	0.74	---
Total	2	4	100.0		
Station 19-1					
Station 20-1					
<i>Brosme brosme</i>	3	6	5.0	1.35-1.40	1.38 $\pm$.04
<i>Merluccius bilinearis</i>	1	2	1.7	0.92	---
<i>Urophycis</i> sp.	38	73	60.1	0.72-0.83	.78 $\pm$.03
<i>Tautoglabrus adspersus</i>	1	2	1.7	0.67	---
<i>Paralichthys oblongus</i>	6	11	9.1	0.96-1.04	.99 $\pm$.03
Unknown 5	1	2	1.7	0.68	---
Unknown 6	9	17	14.0	0.89-0.97	.93 $\pm$.03
Unknown 10	1	2	1.7	0.59	---
Unknown 20	1	2	1.7	0.95	---
Damaged	2	4	3.3	---	---
Total	63	121	100.0		

Table 4 (continued)

BONGO 333

	Number	Standing Crop (No./1000m ³)	Percent Standing Crop	Diameter (mm)	
				Range	Mean $\pm$ S.D.
Station 21-1					
<i>Brevoortia tyrannus</i>	4	17	5.1	1.57-1.64	1.60 $\pm$.04
<i>Brosme brosme</i>	7	29	8.8	1.30-1.39	1.35 $\pm$.03
<i>Merluccius bilinearis</i>	43	178	53.8	0.89-1.00	.95 $\pm$.03
<i>Urophycis</i> sp.	20	83	25.1	0.71-0.83	.77 $\pm$.03
<i>Tautoglabrus adspersus</i>	1	4	1.2	0.76	----
<i>Paralichthys oblongus</i>	3	12	3.6	0.97-1.02	1.00 $\pm$.03
Unknown 10	1	4	1.2	0.76	----
Unknown 21	1	4	1.2	0.85	----
Total	80	331	100.0		
Station 22-1					
<i>Brevoortia tyrannus</i>	4	8	11.8	1.48-1.58	1.52 $\pm$.05
<i>Brosme brosme</i>	8	16	23.5	1.34-1.40	1.38 $\pm$.02
<i>Merluccius bilinearis</i>	6	12	17.6	0.94-0.97	.95 $\pm$.01
<i>Urophycis</i> sp.	9	18	26.6	0.73-0.82	.76 $\pm$.03
<i>Tautoglabrus adspersus</i>	1	2	2.9	0.73	----
<i>Scorpaenopsis scorpaenoides</i>	1	2	2.9	1.12	----
<i>Paralichthys oblongus</i>	2	4	5.9	0.92-1.00	----
Unknown 4	1	2	2.9	0.78	----
Unknown 2	2	4	5.9	0.95-0.96	----
Total	34	68	100.0		
Station 23-1					
<i>Brevoortia tyrannus</i>	2	4	4.0	1.57	----
<i>Brosme brosme</i>	2	4	4.0	1.36	----
<i>Merluccius bilinearis</i>	7	13	12.8	0.92-0.99	.95 $\pm$.02
<i>Urophycis</i> sp.	20	36	35.5	0.74-0.86	.79 $\pm$.03
<i>Tautoglabrus adspersus</i>	1	2	2.0	0.72	----
<i>Paralichthys oblongus</i>	3	5	5.0	0.94-1.01	----
Unknown	18	33	32.7	0.90-0.95	.93 $\pm$.01
Unknown 14	2	4	4.0	0.83-0.84	----
Total	55	101	100.0		

Table 5.--Fish larvae measurements, standing crops, and biomass, Albatross IV cruise 74-5, DWD 106

NEUSTON 947

Number in Sample	Length (mm) Range	Mode	Total Wet Weight (gm)	Standing Crop Number/1000m ²	Biomass Grams/1000m ²
Station 1-1					
<i>Peprilus triacanthus</i>	2	7.8 - 10.0	0.05	0.6	0.01
<i>Limanda ferruginea</i>	3	7.9 - 10.3	0.03	1.3	0.01
Unknown A	5	14.6 - 19.0 (14.6)	0.24	1.6	0.08
Station 2-1					
<i>Muraenidae leptocephalus</i>	2	18.6 - 77.0	0.17	0.8	0.07
<i>Urophycis</i> sp.	12	13.3 - 27.5 (17.5)	0.92	4.9	0.38
<i>Pomatopus saltatrix</i>	22	7.7 - 20.1 (15.2)	0.37	9.0	0.15
<i>Decapterus macarellus</i>	3	35.0 - 37.1	1.85	1.2	0.76
<i>Decapterus punctatus</i>	1	38.7	0.78	0.4	0.32
<i>Selar crumenophthalmus</i>	5	13.4 - 30.4	0.97	2.0	0.40
<i>Seriola</i> sp.	7	8.4 - 29.4 (11.6)	0.71	2.9	0.29
<i>Carangidae</i>	2	7.1 - 7.3	0.02	0.8	0.01
<i>Mugil</i> sp.	34	5.0 - 21.5	0.92	13.9	0.37
<i>Peprilus triacanthus</i>	2	6.2 - 17.0	0.21	0.8	0.09
<i>Stromateoidei</i>	7	8.8 - 15.1	0.41	2.9	0.17
<i>Ariomidae</i>	1	6.8	0.01	0.4	<0.01
<i>Scorpaenidae</i>	1	7.5	0.02	0.4	0.01
<i>Priorotus</i> sp.	1	10.2	0.03	0.4	0.01
<i>Dactylopterus volitans</i>	1	5.8	0.01	0.4	<0.01
<i>Bothidae</i>	1	11.3	0.01	0.4	<0.01
<i>Symphurus</i> sp.	1	11.7	0.02	0.4	0.01
<i>Monacanthus ciliatus</i>	2	8.8 - 9.6	0.04	0.8	0.02
<i>Monacanthus hispidus</i>	42	5.0 - 15.1 (7.0)	1.65	17.2	0.67
<i>Tetraodontidae</i> A	128	4.2 - 14.3 (5.5)	4.79	52.4	1.96
Station 3-1					
<i>Urophycis</i> sp.	253	7.7 - 34.3 (11.5)	8.48	82.0	2.75
<i>Hippocampus erectus</i>	1	69.0	0.97	0.3	0.31
<i>Pomatopus saltatrix</i>	2	17.0 - 37.3	0.71	0.6	0.23
<i>Carangidae</i>	1	10.3	0.02	0.3	0.01
<i>Mugil</i> sp.	10	9.9 - 25.9	1.80	3.2	0.58
<i>Sphyræna borealis</i>	1	33.3	0.18	0.3	0.05
Unknown A	20	7.8 - 20.2	0.70	6.5	0.23

Table 5 (continued)

NEUSTON 947		Number in Sample	Length (mm)		Total Wet Weight (gm)	Standing Crop Number/1000m ²	Biomass Grams/1000m ²
Station 4-1			Range	Mode			
<i>Brevoortia tyrannus</i>		1	21.6		0.09	0.3	0.03
<i>Urophycis</i> sp.		134	6.4 - 40.6	(17.5)	18.01	41.1	5.52
<i>Pomatomus saltatrix</i>		482	7.8 - 33.3	(18.0)	60.23	147.9	18.48
<i>Myctoperca</i> sp.		1	14.9		0.08	0.3	0.23
<i>Deapterus punctatus</i>		2	17.8 - 18.6		0.23	0.6	0.07
<i>Seriola</i> sp.		5	9.4 - 25.7		0.86	1.5	0.26
<i>Trachinotus carolinus</i>		2	10.8 - 12.5		0.11	0.6	0.03
<i>Carangidae</i>		1	8.0		0.02	0.3	<0.01
<i>Corphaena hippurus</i>		1	23.7		0.16	0.3	0.05
<i>Mugil</i> sp.		70	4.1 - 24.4	(6.0)	2.41	21.5	0.74
<i>Papilius triacanthus</i>		3	8.0 - 10.4		0.09	0.9	0.03
<i>Dactylopterus volitans</i>		1	11.7		0.09	0.3	0.03
<i>Monacanthus hispidus</i>		10	5.1 - 11.0		0.27	3.1	0.08
<i>Tetraodontidae</i> A		90	5.2 - 12.7	(10.4)	7.30	27.6	2.24
Station 5-1							
<i>Urophycis</i> sp.		50	10.0 - 40.6	(22.5)	7.44	40.9	6.09
<i>Scemberox saurus</i>		7	124.0 - 154.0		74.68	5.7	61.09
<i>Pomatomus saltatrix</i>		1	27.6		0.28	0.8	0.22
<i>Mugil</i> sp.		3	22.6 - 24.1	(22.6)	0.64	2.5	0.52
<i>Citharichthys arctifrons</i>		1	16.4		0.03	0.8	0.02
<i>Limanda ferruginea</i>		1	13.6		0.01	0.8	0.01
Unknown A		7	15.7 - 20.0	(19.0)	0.54	5.7	0.44
Station 6-1							
<i>Hygophum hygomi</i>		1	47.3		1.87	0.4	0.83
<i>Myctopium affine</i>		1	37.1		0.63	0.4	0.28
<i>Goniichthys coxoi</i>		1	20.2		0.06	0.4	0.03
<i>Centrobanchus nigro-ocellatus</i>		1	15.2		0.05	0.4	0.03
<i>Symbolophorus veranyi</i>		1	10.7		0.12	0.4	0.05
<i>Histrio histrio</i>		1	5.8 - 33.3	(9.3)	15.63	134.1	6.92
<i>Urophycis</i> sp.		303	136.0		9.50	0.4	4.20
<i>Scemberox saurus</i>		1	18.2		0.15	0.4	0.07
<i>Myctoperca</i> sp.		1					

Table 5 (continued)

NEUSTON 947	Number in Sample	Length (mm) Range	Mode	Total Wet Weight (gm)	Standing Crop Number/1000m ²	Biomass Grams/1000m ²
Station 6-1 (Cont.)						
<i>Pristigaster alta</i>	1	11.2		0.10	0.4	0.04
<i>Pomatomus saltatrix</i>	1	28.1		0.29	0.4	0.13
<i>Selar crumenophthalmus</i>	2	20.1 - 31.2		0.51	0.9	0.23
<i>Seriola</i> sp.	7	12.3 - 21.0		1.78	3.1	0.34
<i>Coryphaena hippurus</i>	9	12.9 - 22.1		0.52	4.0	0.23
<i>Mugil</i> sp.	8	17.9 - 25.3		1.65	3.5	0.73
<i>Scomber scombrus</i>	2	38.6 - 47.5		1.64	0.9	0.73
<i>Scombridae</i> (<i>Auxis</i> sp.)	1	13.8		0.04	0.4	0.02
<i>Peprilus triacanthus</i>	3	15.2 - 29.2		1.04	1.3	0.46
<i>Stromateoides</i>	1	10.1		0.04	0.4	0.02
<i>Syngnathus</i>	1	6.8		-	0.4	-
<i>Monacanthus hispidus</i>	1	9.0		-	0.4	-
<i>Balistidae</i>	14	10.6 - 42.8	(16.5)	4.07	6.2	2.24
Station 7-1	1	28.1		1.40	0.4	0.62
<i>Urophycis</i> sp.	35	11.6 - 29.6	(14.5)	2.97	10.3	0.87
<i>Amphelikturus dendriticus</i>	1	29.2		0.02	0.3	0.01
<i>Pomatomus saltatrix</i>	5	21.3 - 26.4		0.56	1.5	0.16
<i>Setiella</i> sp.	4	9.0 - 12.9		0.30	1.2	0.09
<i>Trachinotus falcatus</i>	1	11.0		0.07	0.3	0.02
<i>Mullidae</i>	1	24.8		0.20	0.3	0.06
<i>Mugil</i> sp.	13	8.2 - 16.7	(9.0)	0.37	3.8	0.11
<i>Monacanthus hispidus</i>	2	11.6 - 11.9		0.21	0.6	0.07
<i>Tetraodontidae</i> A	117	4.6 - 11.0	(6.5)	6.46	34.3	1.90
Station 8-1						
<i>Congridae</i> <i>leptocephali</i>	2	81.5 - 84.1		0.45	0.7	0.15
<i>Muraenidae</i> <i>leptocephali</i>	4	33.7 - 82.8		0.72	1.4	0.25
<i>Trachinocephalus myops</i>	2	24.9		-	0.7	-
<i>Lophius americanus</i>	2	10.0 - 14.2		0.10	0.7	0.03
<i>Urophycis</i> sp.	797	6.2 - 22.0	(8.5)	23.37	272.4	7.99
<i>Exocoetidae</i> A.	1	17.2		0.08	0.3	0.03
<i>Scomberesox saurus</i>	6	8.5 - 18.9		0.12	2.1	0.04



Table 5 (continued)

(continued)

NEUSTON 947

Number in Sample		Length (mm)		Total Wet Weight (gm)	Standing Crop Number/1000m ²	Biomass Grams/1000m ²								
Sample		Range												
Station 8-1 (Cont.)														
Holocentridae														
<i>Mycteroperca</i>														
3		5.3 - 6.9		0.02	1.0	0.01								
1		14.5		0.08	0.3	0.03								
100		14.3 - 29.3	(22.0)	12.18	34.2	4.16								
10		21.8 - 31.3	(22.0)	1.88	3.4	0.64								
7		24.3 - 27.0		1.62	2.4	0.55								
8		12.3 - 25.0		1.32	2.7	0.45								
2		7.2 - 10.5		0.09	0.7	0.03								
1		11.8		0.07	0.3	0.03								
2		26.8 - 29.3		0.61	0.7	0.21								
2		19.8 - 22.0		0.21	0.7	0.07								
51		6.7 - 22.0	(6.5)	3.28	17.4	1.12								
2		19.7 - 25.0		0.99	0.7	0.34								
3		8.6		0.02	1.0	0.01								
1		34.5		0.96	0.3	0.33								
1		6.5		0.01	0.3	<0.01								
7		6.5 - 8.0		0.17	2.4	0.06								
1		10.2		0.01	0.3	<0.01								
50		5.3 - 43.4		17.18	17.1	5.87								
42		3.7 - 11.0	(8.0)	16.25	14.4	5.55								
1		11.2		0.01	0.3	<0.01								
Station 9-1														
<i>Urophycis</i> sp.														
163		12.2 - 43.7	(8.0)	9.88	44.5	2.69								
74		14.5 - 31.6		17.94	20.2	4.89								
1		16.8		0.19 ¹⁹	0.3	0.05								
7		12.2 - 27.5		1.28	1.9	0.35								
1		12.0		0.05	0.3	0.01								
1		25.9		0.18	0.3	0.05								
1		42.4		0.43	0.3	0.12								
18		7.1 - 13.8		0.69	4.9	0.19								
1		12.0		0.06	0.3	0.01								
49		9.6 - 44.8		25.45	13.4	6.94								
372		6.3 - 14.1	(8.8)	16.17	101.4	4.41								

Table 5 (continued)

NEUSTON 947

Number in Sample	Length (mm) Range	Total Wet Weight (gm) Mode	Standing Crop Number/1000m ²	Biomass Grams/1000m ²
Station 10-1				
Muraenidae leptocephalus	3	79.2 - 90.8	-	-
Clupeidae	1	25.4	0.14	0.05
Synodontidae	1	16.3	-	-
Urophycis sp.	307	11.5 - 37.2 (14.25)	112.0	11.50
Scorpaenidae	2	8.6 - 13.5	-	-
Myxetopoma	1	10.8	0.04	0.01
Pomatomus saltatrix	35	18.6 - 34.9	6.41	2.34
Caranx batholomaei	1	17.7	0.21	0.08
Cetartus ruber	1	22.6	0.32	0.12
Decapterus punctatus	1	18.8	0.10	0.04
Tharionotus carolinus	2	7.7 - 7.8	0.04	0.02
Seriola sp.	7	18.4 - 35.3	3.93	1.43
Coryphaena equistris	1	20.7	0.14	0.05
Mullidae	6	13.7 - 15.6	0.30	0.11
Mugil sp.	30	6.7 - 17.7	0.90	0.33
Psenes cyanophrys	1	13.4	0.10	0.04
Dactylopterus volitans	3	7.3 - 8.3	0.09	0.03
Cyclopsetta fimbriata	1	17.1	0.11	0.04
Balistidae	1	12.0	0.18	0.06
Monacanthus hispidus	144	7.0 - 55.6 (14.25)	49.37	18.01
Tetraodontidae A	108	5.1 - 13.5 (8.25)	7.27	2.65
Station 11-1				
Urophycis sp.	37	15.6 - 37.0 (21.25)	4.15	1.37
Pomatomus saltatrix	45	15.7 - 30.6	8.50	2.80
Mugil sp.	4	17.1 - 20.4	0.34	0.11
Peprilus triacanthus	2	19.6 - 20.6	0.40	0.13
Station 12-1				
Muraenidae leptocephalus	1	55.5	0.19	0.07
Urophycis sp.	15	17.1 - 31.9 (17.5)	1.35	0.48
Scorpaenidae	3	12.5	0.10	0.04
Hippocanthus erectus	1	91.9	1.66	0.59
Pomatomus saltatrix	18	18.7 - 28.6 (23.5)	3.03	1.08
Mugil sp.	4	15.4	0.05	0.02
Scorpaenidae	1	68.4	3.24	1.15
Tetraodontidae A	1	10.7	0.08	0.03

Table 5 (continued)

NEUSTON 947

	Number in Sample	Length (mm) Range	Mode	Wet Weight (gm)	Standing Crop Number/1000m ²	Biomass Grams/1000m ²
Station 13-1						
<i>Urophycis</i> sp.	12	12.2 - 19.4	(14.0)	0.50	4.3	0.18
<i>Pomatomus saltatrix</i>	14	10.5 - 16.2	(12.5)	0.43	5.0	0.15
<i>Coryphaena hippurus</i>	1	18.0		0.05	0.4	0.02
<i>Mugil</i> sp.	6	8.4 - 21.1		0.53	2.1	0.19
Tetraodontidae A	14	6.5 - 8.5	(7.5)	0.62	5.0	0.22
Station 14-1						
Muraenidae leptocephalus	1	108.9		1.03	0.3	0.34
<i>Trachinocephalus myops</i>	1	20.3		0.01	0.3	<0.01
<i>Urophycis</i> sp.	45	4.8 - 35.0	(14.5)	1.71	14.8	0.56
<i>Scomberesox saurus</i>	1	13.3		0.03	0.3	0.01
<i>Decapterus punctatus</i>	1	12.5		0.03	0.3	0.01
<i>Seriola</i> sp.	5	12.2 - 22.4		0.90	1.6	0.30
<i>Coryphaena equisetis</i>	1	--		0.05	0.3	0.02
<i>Mugil</i> sp.	36	11.8 - 27.3		1.71	11.9	0.56
<i>Polygynus</i> sp.	1	26.5		0.28	0.3	0.09
<i>Peprilus triacanthus</i>	1	7.2		0.01	0.3	<0.01
<i>Dactylopterus volitans</i>	1	14.1		0.14	0.3	0.05
<i>Balistes</i> sp.	1	32.8		1.83	0.3	0.60
<i>Monacanthus hispidus</i>	4	9.2 - 23.5		0.72	1.3	0.24
Tetraodontidae A	17	5.8 - 14.6	(8.5)	2.04	5.6	0.67
Station 15-1						
<i>Urophycis</i> sp.	16	11.0 - 16.8	(11.5)	0.57	4.7	0.17
<i>Scomberesox saurus</i>	1	26.3		0.06	0.3	0.02
<i>Pomatomus saltatrix</i>	6	13.3 - 18.9	(16.5)	0.37	1.8	0.11
<i>Decapterus punctatus</i>	1	11.3		0.02	0.3	0.01
<i>Trachinotus falcatus</i>	1	10.5		0.06	0.3	0.02
<i>Trachinotus carolinus</i>	1	9.1		0.03	0.3	0.01
<i>Mugil</i> sp.	22	6.4 - 24.4	(22.5)	3.06	6.5	0.91
<i>Lactophrys</i>	1	7.3		--	0.3	--
Tetraodontidae A	25	4.8 - 11.9	(10.5)	1.75	7.4	0.52
Tetraodontidae B	1	18.9		0.30	0.3	0.09

Table 5 (continued)

Table 5 (continued)

NEUSTON 947	Number in Sample	Length (mm) Range	Mode	Total Wet Weight (gm)	Standing Crop Number/1000m ²	Biomass Grams/1000m ²
Station 16-1						
<i>Trachinocephalus myops</i>	1	18.8		-	0.4	0.02
<i>Lophius americanus</i>	3	8.6 - 9.2		0.06	1.1	1.25
<i>Urophycis</i> sp.	36	8.4 - 26.4		3.33	21.0	0.30
Exocoetidae A	9	15.5 - 20.2		0.79	3.4	0.02
Exocoetidae B	1	18.9		0.06	0.4	6.28
<i>Pomatomus saltatrix</i>	418	9.4 - 24.9	(12.5)	16.75	156.7	0.16
<i>Decapterus punctatus</i>	8	12.7 - 19.0		0.44	3.0	0.28
<i>Seriola</i> sp.	23	7.0 - 61.8		0.74	8.5	0.34
<i>Coryphaena hippurus</i>	8	14.7 - 26.4		0.90	3.0	0.01
<i>Coryphaena equisetis</i>	1	13.2		0.03	0.4	0.78
<i>Mugil</i> sp.	108	5.5 - 16.9	(8.5)	2.08	40.5	0.06
<i>Peprilus triacanthus</i>	3	16.8		0.15	1.1	0.57
<i>Psenes cyanophrys</i>	1	32.8		1.52	0.4	0.13
Ariomidae	4	7.5 - 15.3		0.35	1.5	0.73
<i>Monacanthus hispidus</i>	61	3.9 - 8.2	(6.0)	1.96	22.9	0.02
Tetraodontidae A	1	14.4		0.05	0.4	
Station 17-1						
<i>Synodus synodus</i>	1	39.8		0.46	0.3	0.15
<i>Trachinocephalus myops</i>	8	20.0 - 29.2		0.28	2.6	0.09
<i>Centrobranchus nigro-ocellatus</i>	8	13.8 - 19.6	(14.0)	0.25	2.6	12.12
<i>Diaphus dumerili</i>	31	26.3 - 56.2		37.70	10.0	3.19
<i>Goniichthys coccoi</i>	55	15.1 - 40.9	(20.25)	9.94	17.7	28.43
<i>Hygophum hygomi</i>	69	26.8 - 54.2		88.45	22.2	10.56
<i>Myctophum affine</i>	194	15.2 - 44.9	(16.5)	32.87	62.4	0.40
<i>Myctophum asperum</i>	27	13.6 - 23.6		1.24	8.7	0.83
<i>Myctophum obtusirostre</i>	17	14.7 - 34.8		2.59	5.5	2.19
<i>Histrio histrio</i>	1	41.4		6.81	0.3	0.04
<i>Urophycis</i> sp.	1	21.2		0.11	0.3	0.21
<i>Hyporhamphus unifasciata</i>	1	52.9		0.66	0.3	0.06
Exocoetidae	2	15.9 - 18.1		0.20	0.6	1.19
<i>Ablennes hians</i>	1	~186		3.72	0.3	0.01
<i>Scomberesox saurus</i>	2	10.1 - 12.4		0.02	0.6	0.01
<i>Syngnathus duceus</i>	1	34.0		0.02	0.3	2.18
<i>Pomatomus saltatrix</i>	34	18.5 - 35.1	(23.0)	6.77	10.9	

Table 5 (continued)

NEUSTON 947

Number in Sample	Length (mm) Range	Mode	Total Wet Weight (gm)	Standing Crop Number/1000m ²	Biomass Grams/1000m ²

Station 17-1 (Cont.)

<i>Decapterus punctatus</i>	5	18.1 - 36.1	(18.5)	1.31	1.6	0.42
<i>Sciaola</i> sp.	4	7.0 - 15.0		0.25	1.3	0.79
<i>Coryphaena hippurus</i>	7	17.1 - 24.4	(17.25)	0.59	2.3	0.19
<i>Coryphaena equisetis</i>	1	17.8		0.08	0.3	0.03
Mullidae	2	27.5 - 27.8		0.50	0.6	0.16
<i>Mugil</i> sp.	11	13.8 - 21.2		1.14	3.5	0.36
<i>Diffloripinnus multistriatus</i>	2	133.0 - 138.0		27.10	0.6	8.71
<i>Scomber scombrus</i>	2	38.2 - 50.6		1.59	0.6	0.51
Bothidae	7	11.8 - 20.2		0.38	2.2	0.17
<i>Menacanthus hispidus</i>	5	12.6 - 61.5		8.11	1.6	2.61

Station 18-1

<i>Trachinocephalus myops</i>	1	23.9		0.02	0.3	0.01
<i>Myctophum obtusirostre</i>	1	16.8		0.02	0.3	0.01
<i>Decapterus punctatus</i>	2	8.4 - 17.7		0.10	0.6	0.03
<i>Mugil</i> sp.	3	7.9 - 20.7		0.19	0.9	0.06
<i>Menacanthus hispidus</i>	5	6.9 - 18.4	(8.5)	0.47	1.5	0.14
Tetraodontidae A	16	4.8 - 13.2	(8.5)	1.24	4.9	0.38

Station 19-1

<i>Astronesthes niger</i>	2	25.9 - 27.0		0.30	0.7	0.11
<i>Trachinocephalus myops</i>	2	23.2 - 25.8		-	0.7	-
<i>Diapylus dumerilli</i>	1	29.8		0.03	0.4	0.01
<i>Goniistius coccoi</i>	21	18.5 - 40.8	(33.0)	6.40	7.6	2.30
<i>Hygophium hygomi</i>	15	25.5 - 53.5		16.33	5.4	5.88
<i>Myctophum affine</i>	115	14.6 - 33.4	(16.5)	11.22	41.4	4.04
<i>Myctophum asperum</i>	1	15.2		0.30	0.4	0.11
<i>Myctophum obtusirostre</i>	1	25.5		0.21	0.4	0.08
<i>Myctophum punctatum</i>	3	22.5 - 26.5		0.60	1.1	0.22
<i>Symbiolophorus verangi</i>	7	20.0 - 51.0		4.56	2.5	1.64
<i>Urophycis</i> sp.	98	14.6 - 33.0	(22.0)	15.55	35.3	5.60
<i>Euleptorhamphus velox</i>	1	~98.5		0.91	0.4	0.33
Serranidae	1	17.0		1.10	0.4	0.04
<i>Pomatomus saltatrix</i>	5	18.2 - 33.8	(31.0)	1.47	1.8	0.53
<i>Catanz hippos</i>	1	22.5		0.34	0.4	0.12

Table 5 (continued)

NEUSTON 947	Number in Sample	Length (mm) Range	Total Wet Weight (gm) Mode	Standing Crop Number/1000m ²	Biomass Grams/1000m ²
Station 19-1 (Cont.)					
<i>Decapterus punctatus</i>	2	24.0 - 39.5	0.99	0.7	0.36
<i>Seriola</i> sp.	2	21.8 - 48.0	2.48	0.7	0.89
<i>Ceryphaena hippurus</i>	1	22.5	0.06	0.4	0.02
<i>Mugil</i> sp.	17	19.0 - 26.5	2.36	6.1	0.85
<i>Scomber scombrus</i>	1	19.5	0.10	0.4	0.04
<i>Peprilus triacanthus</i>	1	26.5	0.42	0.4	0.15
<i>Hypocerygus perciformis</i>	1	30.9	1.08	0.4	0.39
Bothidae	1	20.8	0.12	0.4	0.04
<i>Monacanthus hispidus</i>	10	16.5 - 44.0	7.94	3.6	2.86
Tetraodontidae A	3	9.0	0.13	1.1	0.05
Station 20-1					
<i>Urophycis</i> sp.	69	11.6 - 26.4	4.00	17.1	0.99
<i>Seriola</i> sp.	2	22.2 - 25.5	0.73	0.5	0.18
<i>Mugil</i> sp.	4	9.9 - 14.2	0.17	1.0	0.04
Tetraodontidae A	12	5.9 - 14.2	1.22	3.0	0.30
Tetraodontidae B	1	15.7	0.27	0.2	0.07
Station 21-1					
Congridae leptocephali	1	95.4	0.62	0.3	0.20
<i>Urophycis</i> sp.	25	8.4 - 29.2	2.49	8.1	0.81
<i>Peristomus saltatrix</i>	71	24.4 - 34.7 (29.0)	25.14	23.0	8.14
<i>Mugil</i> sp.	1	24.3	0.26	0.3	0.08
<i>Scomber scombrus</i>	4	9.2 - 10.6	0.09	1.3	0.03
<i>Peprilus triacanthus</i>	1	32.9	1.00	0.3	0.32
Scorpaenidae	1	11.4	0.08	0.3	0.03
<i>Hippoglossoides platesoides</i>	5	10.6 - 14.7	0.11	1.6	0.04
Tetraodontidae A	1	11.2	0.09	0.3	0.03
Unknown A	4	14.6 - 17.9	0.19	1.3	0.06
Unknown C	1	10.3	0.07	0.3	0.02

Table 5 (continued)

NEUSTON 947	Number in Sample	Length (mm) Range	Total Wet Weight (gm)	Standing Crop Number/1000m ²	Biomass Grams/1000m ²
Station 22-1	154	6.8 - 28.7 (18.0)	1.17	49.9	0.38
<i>Urophycis</i> sp.	1	21.1	0.24	0.3	0.08
<i>Epinephelus punctatus</i>	2	11.0 - 14.1	0.07	0.6	0.02
<i>Decapterus punctatus</i>	7	22.0 - 26.7	1.60	2.3	0.52
<i>Mugil</i> sp.	1	10.2	0.01	0.3	<0.01
<i>Hippoglossoides platessoides</i>	1	19.0	0.30	0.3	0.10
<i>Monacanthus hispidus</i>					
Station 23-1	920	10.4 - 32.4 (13.0)	48.18	365.3	19.13
<i>Urophycis</i> sp.	1	14.1	0.10	0.4	0.04
<i>Scomberesox saurus</i>	218	12.3 - 32.7	27.25	86.6	10.82
<i>Pomatomus saltatrix</i>	9	11.2 - 25.2	1.60	3.6	0.63
<i>Mugil</i> sp.	2	31.2 - 33.7	0.29	0.8	0.12
<i>Spiracna borealis</i>	1	17.6	0.21	0.4	0.08
<i>Monacanthus hispidus</i>	9	6.7 - 12.7 (10.0)	0.72	3.6	0.28
Tetraodontidae A					

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Table 6.--Fish larvae measurements and standing crops, Albatross IV
cruise 74-5, Bongo net samples, Deepwater Dumpsite 106.

Table 3. Length (mm) and Standing Crop (No./1000m³) of fish caught on Bongo net samples, Deepwater Dumpsite 100.

BONGO 505	Number	Length (mm) Range	Standing Crop No./1000m ³
<u>Station 1-1</u>			
Paralepididae	1	19.3	5.2
Myctophidae	1	6.8	5.2
<i>Lophius americanus</i>	1	7.0	5.2
<i>Limanda ferruginea</i>	7	5.8 - 8.5	36.6
<u>Station 2-1</u>			
Muraenidae leptocephalus	1	25.8	2.8
<i>Diogenichthys atlanticus</i>	1	5.0	2.8
Moridae	8	5.6 - 14.1	22.0
Macrouridae	1	15.3	2.8
Holocentridae	1	6.7	2.8
<i>Bothus</i> sp.	1	5.3	2.8
<i>Citharichthys</i> sp.	1	6.5	2.8
<i>Monacanthus ciliatus</i>	1	6.8	2.8
Tetraodontidae A	1	5.3	2.8
<u>Station 3-1</u>			
<i>Brevoortia tyrannus</i>	1	2.4	6.2
<i>Anchoa</i> sp.	1	9.5	6.2
Myctophidae	9	3.9 - 6.0	55.9
<i>Urophycis</i> sp.	2	3.1 - 8.8	12.4
<i>Pomatomus saltatrix</i>	1	20.2	6.2
<i>Limanda ferruginea</i>	2	9.1 - 9.5	12.4
Unknown D	7	3.7 - 4.8	43.5
<u>Station 4-1</u>			
<i>Nettodarus brevirostris</i>	1	32.7	2.8
Myctophidae	2	3.2 - 3.3	6.6
Gonostomatidae	1	----	2.8
Serranidae	2	6.3 - 13.7	6.6
<i>Etropus microstomus</i>	1	8.2	2.8
<i>Syacium</i> sp.	1	5.7	2.8
Bothidae	3	3.0 - 5.6	8.4
<i>Monacanthus hispidus</i>	1	4.7	2.8
Unknown D	1	4.5	2.8
Unknown E	1	5.3	2.8
<u>Station 5-1</u>			
<i>Brevoortia tyrannus</i>	1	3.7	4.4
<i>Ceratoscopelis maderensis</i>	2	8.0 - 8.2	8.8
Myctophidae	25	6.2 - 10.1	111.1
<i>Urophycis</i> sp.	1	19.5	4.4
<i>Scomber scombrus</i>	1	8.2	4.4
<i>Peprilus triacanthus</i>	1	5.6	4.4
<i>Limanda ferruginea</i>	4	8.3 - 9.9	17.8
Bothidae	1	7.6	4.4

Table 6 (continued)

BONGO 505	Number	Length (mm) Range	Standing Crop No./1000m ³
<u>Station 5-1 (Cont.)</u>			
<i>Symphurus</i> sp.	1	9.0	4.4
<i>Monacanthus hispidus</i>	1	10.2	4.4
Tetraodontidae A	1	5.0	4.4
Unknown V	1	5.5	4.4
<u>Station 6-1</u>			
<i>Lepidophanes guentheri</i>	1	23.0	3.0
<i>Myctophum asperum</i>	1	16.6	3.0
Macrouridae	1	41.9	3.0
<i>Peprilus triacanthus</i>	1	8.1	3.0
Bothidae	1	10.9	3.0
Unknown D	1	3.5	3.0
<u>Station 7-1</u>			
<i>Anchoa</i> sp.	1	9.9	2.5
Clupeiformes	1	13.5	2.5
<i>Maurolicus muelleri</i>	1	7.4	2.5
<i>Trachinocephalus myops</i>	1	16.6	2.5
Synodontidae	1	6.6	2.5
Myctophidae	37	4.7 - 10.0	92.5
<i>Urophycis</i> sp.	3	2.8 - 14.2	7.5
<i>Lophius americanus</i>	1	3.9	2.5
Scorpaenidae	1	4.8	2.5
Bothidae	1	6.4	2.5
<i>Cyclopsetta fimbriata</i>	1	13.2	2.5
<i>Etropus microstomus</i>	1	6.0	2.5
<i>Syacium</i> sp.	2	4.0 - 8.2	5.0
<i>Symphurus</i> sp.	1	9.0	2.5
Tetraodontidae A	1	4.8	2.5
Unknown D	2	4.3 - 5.0	5.0
Unknown 6	4	4.0 - 5.0	10.0
<u>Station 8-1</u>			
<i>Bonapartia pedaliota</i>	1	14.6	3.1
<i>Centrobranchus</i> sp.	1	9.6	3.1
<i>Ceratoscopelus maderensis</i>	3	6.6 - 8.1	9.4
Myctophidae	7	3.8 - 9.8	21.9
Moridae	1	19.0	3.1
Macrouridae	3	17.4 - 6.3	9.4
Holocentridae	1	7.6	3.1
<i>Centropristis striata</i>	1	4.4	3.1
<i>Cyclopsetta fimbriata</i>	1	9.6	3.1
Tetraodontidae A	2	9.2 - 9.8	6.3

Table 6 (continued)

BONGO 505	Number	Length (mm) Range	Standing Crop No./1000m ³
<u>Station 9-1</u>			2.7
Clupeiformes	1	11.1	2.7
Paralepididae	1	9.0	29.8
Myctophidae	11	4.6 - 10.0	2.7
<i>Citharichthys arctifrons</i>	1	5.4	2.7
<i>Cyclopsetta fimbriata</i>	1	14.4	2.7
<i>Syacium</i> sp.	1	4.0	2.7
Tetraodontidae A	1	6.8	2.7
Unknown H	1	8.1	2.7
Unknown J	1	3.4	2.7
Unknown L	1	5.6	
<u>Station 10-1</u>			6.1
Gonostomatidae	2	6.8 - 11	6.1
Myctophidae	2	3.4 - 7.7	6.1
<i>Urophycis</i> sp.	2	9.7 - 12.6	3.0
Moridae	1	7.2	3.0
Exocoetidae	1	20.4	3.0
<i>Pomatomus saltatrix</i>	1	15.6	3.0
<i>Peprilus triacanthus</i>	1	3.7	6.1
<i>Citharichthys arctifrons</i>	2	5.0 - 5.5	3.0
<i>Syacium</i> sp.	1	4.6	6.1
Unknown D	2	4.2 - 4.7	6.1
Unknown K	2	6.2 - 9.4	3.0
Unknown L	1	8.7	
<u>Station 11-1</u>			89.6
Myctophidae	24	3.5 - 8.9	7.5
Unknown D	2	5.1 - 5.6	
<u>Station 12-1</u>			3.7
Gonostomatidae	1	13.5	22.1
Myctophidae	6	2.4 - 8.5	3.7
Sciaenidae	1	3.1	3.7
Unknown D	1	3.8	
<u>Station 13-1</u>			3.4
Nettastomatidae leptocephalus	1	131.2	3.4
<i>Brevoortia tyrannus</i>	1	6.8	3.4
Clupeiformes	1	5.3	6.8
Synodontidae	2	5.1 - 6.3	41.1
Myctophidae	12	3.4 - 9.7	3.4
<i>Pomatomus saltatrix</i>	1	5.8	3.4
<i>Peprilus triacanthus</i>	1	4.2	6.8
Bothidae	2	4.2 - 6.3	3.4
Tetraodontidae A	1	3.9	3.4
Unknown G	1	4.2	3.4
Unknown R	1	5.1	

Table 6 (continued)

BONGO 505		Length (mm)	Standing Crop
	Number	Range	No./1000m ³
<u>Station 14-1</u>			
<i>Argyrops leucogymnus</i>	1	9.1	2.8
Synodontidae	1	10.0	2.8
Myctophidae	13	5.3 - 9.9	36.6
<i>Histrio histrio</i>	1	7.5	2.8
<i>Antigonia</i> sp.	1	7.4	2.8
Bothidae	1	8.9	2.8
<i>Syacium</i> sp.	1	7.8	2.8
<i>Monacanthus hispidus</i>	2	9.8 - 24.3	5.6
Unknown K	1	9.8	2.8
Unknown L	1	9.0	2.8
<u>Station 15-1</u>			
Gonostomatidae	1	7.0	3.0
Myctophidae	2	n.m.	6.1
Bothidae	2	6.2 - 7.0	6.1
Unknown O	1	4.1	3.0
<u>Station 16-1</u>			
<i>Brevoortia</i> sp.	2	8.2 - 9.9	4.8
Synodontidae	1	4.7	2.4
Myctophidae	8	5.0 - 15.6	19.3
<i>Urophycis</i> sp.	1	5.7	2.4
<i>Pomatomus saltatrix</i>	3	3.8 - 6.3	7.2
<i>Stenotomus chrysops</i>	1	4.8	2.4
Scombridae	1	5.7	2.4
<i>Peprilus triacanthus</i>	1	3.2	2.4
<i>Prionotus</i> sp.	1	3.3	2.4
<i>Syacium</i> sp.	1	4.2	2.4
Bothidae	6	3.4 - 7.5	14.5
Unknown D	1	5.2	2.4
Unknown H	1	5.2	2.4
Unknown P	2	4.2 - 4.6	4.8
<u>Station 17-1</u>			
Paralepididae	1	6.2	2.8
Gonostomatidae	1	7.4	2.8
<i>Trachinocephalus myops</i>	1	17.1	2.8
Evermannellidae	1	24.5	2.8
<i>Diaphus dumeril</i>	4	15.6 - 29.7	11.2
<i>Hygophum hygomi</i>	1	39.3	2.8
<i>Lobianchia dolgoleini</i>	1	20.6	2.8
<i>Myctophum affine</i>	1	17.2	2.8
Myctophidae	8	4.3 - 8.2	22.4
Macrouridae	1	43.3	2.8
<i>Pomatomus saltatrix</i>			
Serranidae	2	18.7 - 21.1	5.6
<i>Peprilus triacanthus</i>	1	3.3	2.8
Bothidae	3	5.3 - 14.2	8.4
Tetraodontidae A	2	3.0 - 5.3	5.6
Unknown H	1	9.1	2.8
Unknown L	1	9.1	2.8

Table 6 (continued)

BONGO 505	Number	Length (mm) Range	Standing Crop No./1000m ³
<u>Station 18-1</u>			
Myctophidae	25	3.7 - 7.0	42.2
<i>Histrio histrio</i>	1	3.2	1.7
<i>Urophycis</i> sp.	4	1.8 - 2.8	6.7
Macrouridae	3	17.4 - 33.2	5.1
Serranidae	1	17.7	1.7
Apogonidae	1	12.3	1.7
Gempylidae	1	9.8	1.7
<i>Peprilus triacanthus</i>	1	14.2	1.7
Stromateidae	1	7.5	1.7
<i>Cyclopsetta fimbriata</i>	3	5.0 - 6.6	5.1
<i>Syacium</i> sp.	14	3.6 - 6.2	23.6
Bothidae	33	4.9 - 11.6	55.6
Unknown D	16	3.0 - 4.0	27.0
Unknown H	1	7.2	1.7
Unknown K	2	8.0 - 14.0	3.4
Unknown L	6	5.8 - 8.0	10.1
<u>Station 19-1</u>			
Congridae leptocephalus	1	98.9	1.4
Paralepididae	1	23.9	1.4
<i>Valenciennellus</i>	2	7.5 - 9.3	2.9
<i>tripunctulatus</i>			
<i>Vincigerria powerial</i>	1	19.9	1.4
<i>Benthoosema suborbitale</i>	3	13.2 - 21.1	4.3
<i>Ceratoscopelus maderensis</i>	2	6.6 - 7.3	2.9
<i>Diaphus dumerili</i>	1	13.9	1.4
<i>Hygophum hygomi</i>	2	23.4 - 51.9	2.9
<i>Lampanyctus alatus</i>	1	19.9	1.4
<i>Lepidophanes guentheri</i>	1	29.4	1.4
<i>Myctophum asperum</i>	3	12.2 - 12.8	4.3
Myctophidae	32	6.0 - 9.8	46.2
<i>Lophius americanus</i>	2	25.6 - 28.6	2.9
<i>Urophycis</i> sp.	2	18.3 - 20.1	2.9
Melamphaeidae	1	15.5	1.4
<i>Syngnathus elucens</i>	1	30.9	1.4
<i>Pomatomus saltatrix</i>	1	20.0	1.4
<i>Peprilus triacanthus</i>	1	9.0	1.4
Stromateidae	1	19.2	1.4
<i>Citharichthys arctifrons</i>	1	7.7	1.4
Bothidae	5	5.2 - 12.8	7.2
Unknown H	2	7.2 - 9.0	2.9
Unknown Q	1	6.1	1.4

Table 6 (continued)

BONGO 505

	Number	Length (mm) Range	Standing Crop No./1000m ³
Station 20-1			
Congridae leptocephalus	1	51.4	2.0
Ceratoscopelus maderensis	3	5.4 - 6.8	5.9
Myctophidae	12	3.3 - 6.8	23.6
Moridae	1	31.9	2.0
Stromateidae	1	15.1	2.0
Bothidae	2	5.2 - 6.0	3.9
Tetraodontidae B	1	12.2	2.0
Unknown D	4	3.5 - 4.7	7.9
Unknown R	1	8.3	2.0
Station 21-1			
Nettastomatidae	1	108.0	4.4
leptocephalus			
Scomber scombrus	11	3.7 - 6.2	48.3
Peprilus triacanthus	1	9.2	4.4
Limanda ferruginea	14	6.4 - 10.2	61.4
Station 22-1			
Paralepididae	1	24.9	2.0
Synodontidae	1	7.8	2.0
Myctophidae	4	3.8 - 9.4	8.0
Scomber scombrus	13	3.0 - 5.6	26.1
Bothidae	1	19.6	2.0
Unknown D	1	5.0	2.0
Unknown L	1	7.2	2.0
Station 23-1			
Muraenidae leptocephalus	1	60.6	1.9
Urophycis sp.	21	10.3 - 22.6	39.0
Pomatomus saltatrix	4	14.6 - 19.2	7.4
Peprilus triacanthus	1	12.1	1.9
Limanda ferruginea	1	----	1.9
Monacanthus hispidus	1	8.9	1.9
Unknown A	1	17.6	1.9

Table 6 (continued)

BONGO 333	Number	Length (mm) Range	Standing Crop No./1000m ³
<u>Station 1-1</u> No sample taken			
<u>Station 2-1</u>			
Paralepididae	2	5.0 - 7.4	5.3
Valenciennellus			
tripunctulatus	2	6.9 - 9.1	5.3
Synodontidae	1	6.8	2.7
Myctophidae	5	3.7 - 7.5	13.3
Moridae	2	5.0 - 7.4	5.3
Peprilus triacanthus	2	5.2 - 5.9	5.3
Bothidae	2	4.7 - 5.1	5.3
Unknown K	2	6.2 - 8.6	5.3
Unknown S	1	3.3	2.7
<u>Station 3-1</u>			
Ceratoscopelus maderensis	1	11.8	6.0
Myctophidae	9	5.1 - 7.3	54.2
Limanda ferruginea	1	7.3	6.0
Unknown D	3	3.8 - 4.3	18.1
<u>Station 4-1</u>			
Muraenidae leptocephali	1	17.1	3.1
Clupeidae	1	13.7	3.1
Histrio histrio	1	4.8	3.1
Myctophidae	8	3.9 - 5.9	24.4
Bothidae	4	4.0 - 6.3	12.2
<u>Station 5-1</u>			
Myctophidae	31	5.9 - 10.2	200.0
Merluccius bilinearis	1	3.4	6.5
Peprilus triacanthus	1	4.7	6.5
Citharichthys arctifrons	1	11.1	6.5
Limanda ferruginea	1	----	6.5
Unknown K	1	9.3	6.5
Unknown T	1	9.5	6.5
<u>Station 6-1</u>			
Ophichthidae leptocephali	1	42.0	2.9
Myctophidae	3	5.8 - 9.1	8.6
Apogonidae	1	8.8	2.9
Ariommidae	1	13.4	2.9
Syacium sp.	1	6.5	2.9
Bothidae	1	6.0	2.9
Unknown D	1	5.3	2.9

Table 6 (continued)

BONGO 333	Number	Length (mm) Range	Standing Crop No./1000m ³
<u>Station 7-1</u>			
Stomiatidae	1	15.3	2.7
Gonostomatidae	1	29.7	2.7
Valenciennellus			
<i>tripunctulatus</i>	2	6.2 - 6.4	5.4
Myctophidae	33	3.9 - 10.6	90.5
Moridae	1	9.8	2.7
Gempylidae	1	3.5	2.7
Scorpaenidae	1	3.1	2.7
Bothidae	2	7.6	5.4
<i>Cyclopsetta fimbriata</i>	1	7.0	2.7
<i>Syacium</i> sp.	1	4.0	2.7
<i>Monacanthus hispidus</i>	4	11.8 - 19.7	11.0
Tetraodontidae	1	6.3	2.7
Unknown E	1	5.3	2.7
Unknown T	1	7.5	2.7
<u>Station 8-1</u>			
Congridae leptocephali	1	60.6	3.0
Clupeidae	1	-----	3.0
Paralepididae	4	5.6 - 8.7	12.0
Valenciennellus			
<i>tripunctulatus</i>	1	6.2	3.0
<i>Vinciguerrria</i> sp.	1	16.0	3.0
Synodontidae	2	5.6 - 6.6	6.0
Myctophidae	7	4.5 - 9.7	21.0
<i>Bregmaceros atlanticus</i>	1	15.4	3.0
<i>Urophycis</i> sp.	1	6.3	3.0
<i>Syngnathus</i> sp.	1	28.4	3.0
Serranidae	1	7.9	3.0
Bothidae	1	5.9	3.0
Cynoglossidae	2	9.1 - 11.7	6.0
Unknown D	3	4.4 - 5.9	9.0
Unknown C	1	9.1	3.0
<u>Station 9-1</u>			
Myctophidae	18	5.3 - 8.0	46.3
<i>Peprilus triacanthus</i>	1	3.6	2.6
Tetraodontidae A	1	9.7	2.6
<u>Station 10-1</u>			
Congridae leptocephali	2	59.2 - 114.1	5.7
Paralepididae	1	-----	2.9
Myctophidae	1	10.2	2.9
<i>Urophycis</i> sp.	1	11.0	2.9
Macrouridae	1	38.6	2.9
Serranidae	1	5.6	2.9
Scorpaenidae	1	7.3	2.9
<i>Citharichthys arctifrons</i>	1	8.9	2.9
Unknown K	1	13.6	2.9
Unknown U	1	5.6	2.9

Table 6 (continued)

Table 6 (continued)

BONGO 333	Number	Length (mm) Range	Standing Crop No./1000m ³
<u>Station 11-1</u>			
Clupeidae	1	-----	2.9
Stomiatidae	.2	19.1 - 20.1	5.8
Myctophidae	17	3.6 - 8.7	49.7
<u>Station 12-1</u>			
Argentinidae	1	7.2	3.5
Myctophidae	16	2.7 - 8.3	56.3
Sciaenidae	2	2.8 - 4.1	7.0
Bothidae	1	18.1	3.5
Unknown D	3	4.3 - 6.3	10.6
<u>Station 13-1</u>			
<i>Valenciennellus tripunctulatus</i>	1	8.3	3.3
Myctophidae	17	3.4 - 8.4	55.9
<i>Pomatomus saltatrix</i>	1	3.0	3.3
<i>Peprilus triacanthus</i>	1	13.9	3.3
Bothidae	1	6.8	3.3
Unknown D	2	4.5 - 6.0	6.6
Unknown V	1	6.8	3.3
Unknown W	1	1.9	3.3
<u>Station 14-1</u>			
Clupeidae	1	17.2	2.7
Paralepididae	1	11.5	2.7
Myctophidae	16	6.2 - 9.6	43.6
<i>Centropristis striata</i>	1	8.4	2.7
<i>Pomatomus saltatrix</i>	1	5.5	2.7
<i>Peprilus triacanthus</i>	1	4.1	2.7
<i>Syacium</i> sp.	1	4.8	2.7
Bothidae	2	5.5 - 15.3	5.5
Cynoglossidae	1	5.1	2.7
<u>Station 15-1</u>			
<i>Valenciennellus tripunctulatus</i>	1	8.0	2.9
<i>Vinciguerrria nimbaria</i>	1	16.3	2.9
<i>Trachinocephalus myops</i>	1	11.4	2.9
Myctophidae	2	7.1 - 7.2	5.9
<i>Urophycis</i> sp.	1	5.7	2.9
Bothidae	3	6.3 - 16.1	8.8
Unknown T	1	9.0	2.9

Table 6 (continued)

BONGO 333	Number	Length (mm)	Standing Crop No./1000m ³
		Range	
<u>Station 16-1</u>			
Muraenidae leptocephali	1	26.4	2.3
Chauliodus sp.	1	36.6	2.3
Myctophidae	5	7.4 - 10.0	11.2
Histrio histrio	1	3.5	2.3
Urophycis sp.	1	3.9	2.3
Moridae	1	11.0	2.3
Macrouridae	1	32.9	2.3
Serranidae	1	7.3	2.3
Pomatomus saltatrix	1	6.1	2.3
Cithanrichthys arctifrons	1	10.3	2.3
Syacium sp.	2	4.4 - 14.1	4.6
Bothidae	2	6.3 - 16.5	4.6
Unknown K	1	11.4	2.3
<u>Station 17-1</u>			
Gonostoma elongatum	2	15.7 - 21.4	5.6
Valenciennellus tripunctulatus	1	5.5	2.8
Vinciguerrria poweriae	1	14.7	2.8
Ceratospopelus maderensis	1	19.7	2.8
Diaphus dumerili	6	20.0 - 35.2	16.8
Lepidophanes guntheri	1	16.7	2.8
Notolychnus valdiviae	1	18.5	2.8
Bothidae	1	7.6	2.8
<u>Station 18-1</u>			
Clupeidae	1	----	1.7
Valenciennellus tripunctulatus	1	6.5	1.7
Myctophidae	37	4.1 - 9.9	63.1
Urophycis sp.	1	4.0	1.7
Macrouridae	1	----	1.7
Holocentridae	1	12.0	1.7
Scombridae	9	1.9 - 4.3	15.4
Peprilus triacanthus	1	4.4	1.7
Stomiatoidei	1	12.3	1.7
Scorpaenidae	1	5.6	1.7
Syacium sp.	23	3.6 - 7.1	39.2
Bothidae	47	4.0 - 8.4	80.4
Cynoglossidae	1	4.2	1.7
Monacanthus ciliatus	1	14.9	1.7
Unknown D	88	3.4 - 5.4	150.2
Unknown H	4	5.7 - 10.6	6.8
Unknown I	1	3.6	1.7
Unknown M	1	13.0	1.7
Unknown O	1	4.1	1.7
Unknown T	9	4.9 - 9.6	15.4
Unknown X	1	5.6	1.7
Unknown Y	1	2.3	1.7

Table 6 (continued)

Table 6 (continued)

BONGO 333	Number	Length (mm) Range	Standing Crop No./1000m ³
<u>Station 19-1</u>			
Congridae leptocephalus	1	75.2	1.6
Paralepididae	2	24.2 - 37.8	3.3
Stomias boaferox	1	150.5	1.6
Valenciennellus tripunctulatus	1	9.3	1.6
Synodontidae	1	8.9	1.6
Bethosema glaciale	1	43.8	1.6
Bethosema suborbitale	1	21.2	1.6
Ceratoscopelus maderensis	14	5.7 - 8.3	22.8
Diaphus rafinesquei	2	21.3 - 21.6	3.3
Diogenichthys atlanticus	2	18.5 - 21.6	3.3
Electrona rissoi	1	16.5	1.6
Lampanyctus pusillus	1	21.1	1.6
Lampanyctus sp.	1	15.5	1.6
Lepidophanes gaussi	2	16.1 - 23.7	3.3
Myctophum affine	3	17.1 - 26.7	4.9
Myctophum punctatum	1	30.5	1.6
Myctophidae	46	5.9 - 16.8	74.8
Bregmaceros atlanticus	1	16.7	1.6
Scomber scombrus	1	4.2	1.6
Peprilus triacanthus	1	14.0	1.6
Scorpaenidae	1	7.7	1.6
Bothidae	2	5.7 - 6.7	3.3
Tetraodontidae A	1	5.6	1.6
Unknown H	1	9.8	1.6
Unknown N	2	10.9 - 14.5	3.3
Unknown T	5	7.3 - 10.5	8.1
<u>Station 20-1</u>			
Clupeidae	2	4.2 - 6.1	3.6
Paralepididae	1	16.0	1.9
Ceratoscopelus maderensis	10	6.3 - 13.6	19.1
Myctophidae	15	3.5 - 5.8	28.6
Bothidae	4	5.4 - 6.3	7.6
Unknown D	5	3.1 - 3.8	9.5
Unknown H	1	10.4	1.9
Unknown L	1	6.0	1.9
Unknown R	2	4.5 - 4.7	3.6

BONGO 333

Table 6 (continued)

	Number	Length (mm) Range	Standing Crop No./1000m ³
<u>Station 21-1</u>			
Nettastomatidae			
leptocephalus	1	113.7	4.2
Valenciennellus			
tripunctulatus	2	7.4 - 7.9	8.3
Myctophidae	5	3.6 - 6.6	20.7
Bregmaceros atlanticus	1	23.6	4.2
Ophidiidae	1	15.1	4.2
Scomber scombrus	11	3.5 - 5.4	45.6
Limanda ferruginea	9	6.9 - 9.6	37.3
Bothidae	1	9.2	4.2
<u>Station 22-1</u>			
Myctophidae	7	5.1 - 7.0	13.6
Merluccius bilinearis	1	3.9	1.9
Urophycis sp.	2	4.0	3.9
Pomatomus saltatrix	1	---	1.9
Scomber scombrus	6	4.1 - 6.4	11.7
Limanda ferruginea	4	5.2 - 7.3	7.8
Unknown T	1	7.3	1.9
<u>Station 23-1</u>			
Paralepididae	1	21.5	1.8
Myctophidae	1	5.5	1.8
Urophycis sp.	14	8.2 - 16.1	25.4
Pomatomus saltatrix	2	19.3 - 23.0	3.6

Table 7.--Zooplankton standing crops, Deepwater Dumpsite 106, Albatross IV
cruise 74-5

NEUSTON 947--standing crop (number per 1000 m²)

Stations	1	2	3	4	5	6	7	8	9	10	11
Taxa											
Siphonophora											
Chaetognatha	858	549	21	1738	576	609	75	218	181	117	3
Polychaete	66			15							11
Gastropoda (L)#	1			5							11
Pteropoda	52	21	25		53	49					
Heteropoda	39	3732	137		778						3
Cephalopoda											
Cladocera											
Ostracoda						7					
Mysidaceae	15										
Amphipoda	66	117	435	34		49	19	1268	11	198	5
Isopoda	30		21	5	53	14			41	35	23
Euphausiacea	15	92	10	5	12409	135		6211	98	117	
Decapoda											
(Caridian) (L)	261		63		53	14	28	393	4	140	3
Decapoda*											
(Brachyura) (L)	457	1061	41	79	6965	163	19	5905	8	1086	63
Copelata											
Salpida											

Stations	12	13	14	15	16	17	18	19	20	21	22	23
Taxa												
Siphonophora			5				299					
Chaetognatha	23	271	655	458	1992	268	143	657	2	705	57	197
Polychaete	3	23			19		3					5
Gastropoda#(L)#					6			11				5
Pteropoda	3					283						4
Heteropoda		3	18		6							112
Cephalopoda												
Cladocera												
Ostracoda												
Mysidaceae					6							
Amphipoda	43	3	74	5	6	57		196	2	1037	192	6
Isopoda	73	3	29			16	5	11	44		10	60
Euphausiacea	8	3	3		12	221	5	610	2	456	171	4
Decapoda												
(Caridian) (L)	5	8	81	24	150	62	5	34	4	26	26	4
Decapoda*												
(Brachyura) (L)	321	3	281	16	6	468	49	357	4	2224	547	6
Copelata												
Salpida				3			77					

Larvae.

* Includes Stomatopod larvae.

Table 7.--Zooplankton standing crop (continued)

BONGO 505--standing crop (number per 1000 m ³)												
Stations	1	2	3	4	5	6	7	8	9	10	11	
Taxa												
Siphonophora	-----140--2404											
Chaetognatha	---29943-	3173-	32203-	7502-	11659-	16499-	10636-	18431-	8408-	10204-	8721	
Polychaeta	-----4098-	419--	149--	268--	142-----	-----	220--	501--	65--	875--	30	
Gastropoda (L) #	-----160--250											
Pteropoda	-----35798-	1498-	2460-	1250-	5900--	1043--	1459--	4407-----	-----	729--	718	
Heteropoda	-----200--43											
Cephalopoda	-----84											
Cladocera	-----962-----	-----569										
Ostracoda	-----837--	199--	804--	213--	427--	140--	2755--	173--	340--	90		
Mysidaceae												
Amphipoda	-----42--	639--	2882--	759--	355--	1707--	620--	3456--	282--	1409--	448	
Isopoda	-----66-----	-----45-----		-----95-----		22-----		97				
Euphausiacea	---15055-	1080-	31209-	2143-	12974-	6590--	3959--	6010-	1585--	5782-	4002	
Decapoda												
(Caridian) (L)	---293-	1080--	199--	670-----	-----47--		1439--	250--	217--	243		
Decapoda*												
(Brachyura) (L)	-10371-	1124--	1938--	625--	2026--	1090--	1559--	1803--	433--	1846--	119	
Copelata	-----836-----	-----199--		1161--	178--	284--	320--	4858--	108--	1409		
Salpida	-----441--	50--	625--	284--	780--	1052--	87--	826				
Stations	12	13	14	15	16	17	18	19	20	21	22	23
Taxa												
Siphonophora	---207--	767-----	-----674-----		-----277-----		-----351--		481--	134		
Chaetognatha	---6198-	11727-	17675-	5312-	10889-	7097-	14669-	12465-	2520-	23558-	4006-	5224
Polychaeta	-----30--	137--	271--	244--	116--	180--	539-----	79-----	70--	64		
Gastropoda (L) #	---885--	110-	18775-	-----185-----		-----64--45						
Pteropoda	---2036-	1973--	1623--	804--	2703--	-----3236--		3509--	410-	29728-	3076--	861
Heteropoda	-----55-----	-----70--32--								74		
Cephalopoda	-----24-----108--92											
Cladocera	-----280--208											
Ostracoda	---207--	685--	1713--	195--	579-	1392--	2912--	1847--	173--	280--	144--	89
Mysidaceae												
Amphipoda	---1800--	548--	1713--	804--	1738-	1392--	5177--	1939-	1181--	911--	240--	668
Isopoda	-----30-----	-----90-----		-----647-----		16						
Euphausiacea	---4575-	2466--	5411-	1389--	4055--	-----5070-		10249-	4395--	5539-	7307-	2196
Decapoda												
(Caridian) (L)	--89--	548--	631--	244--	1158-	9971--	1510--	831--	284--	280--	32--	104
Decapoda*												
(Brachyura) (L)	59--	1918--	2886-	1218--	2278--	90--	4099--	1570--	441-	16266--	288--	74
Copelata	-----30--	2850--	1353--	122--	193--	-----539-----		221--	70--	176--	15	
Salpida	-----521--	1533--	97--	77--	719--	1402--	-----299--		70--	-----15		

Larvae.

* Includes Stomatopod larvae.

Table 7.--Zooplankton standing crop (continued)
BONGO 333--standing crop (number per 1000 m³)

Stations	1	2	3	4	5	6	7	8	9	10	11
Taxa											
Siphonophora	-----596-----		-----1078-----	-----4017-----	-----2059-----	-----2106-----	-----958-----				
Chaetognatha	-----7751-----	50702	-----16704-----	-----44184-----	-----21230-----	-----24171-----	-----30513-----	7971	-----18854-----	8033	
Polychaeta (L) #	-----1704-----	-----551-----	-----833-----	-----1751-----	-----183-----	-----1009-----	-----766-----	-----267-----	-----1196-----		
Gastropoda (L)	2044	-----	-----931-----	37489	-----458-----	-----263-----	-----192-----			-----1031-----	
Pteropoda	-----	-----21080-----		-----206-----	-----732-----	-----3067-----	-----1006-----	2013	-----3127-----	23	
Heteropoda	-----	-----	-----147-----		-----275-----	-----1404-----	-----1581-----				
Cephalopoda											
Cladocera	-----	-----	-----	-----2472-----							
Ostracoda	-----	4216	-----2204-----	-----6809-----	-----721-----	-----2105-----	-----1097-----	-----2491-----	-----1931-----	-----1747-----	
Mysidaceae	-----							-----48-----			
Amphipoda	NO	-----1235-----	19151	-----784-----	-----3399-----	-----2059-----	-----1141-----	-----3209-----	-----678-----	-----1793-----	1710
Isopoda	-----							-----96-----			
Euphausiacea	-----	4813	53182	-----3135-----	34194	-----6955-----	-----5001-----	5796	-----1808-----	5334	
Decapoda											
(Caridian) (L)	-----		-----138-----	-----1861-----		-----46-----	-----1623-----	-----240-----	-----123-----	-----138-----	3981
Decapoda*											
(Brachyura) (L)	-----	85	-----	-----196-----	-----2163-----	-----2059-----	-----1097-----	-----1533-----	-----1089-----	-----2529-----	70
Copelata	-----		-----827-----			-----5582-----			-----472-----	-----3495-----	
Salpida	-----	3153	-----276-----	-----490-----		-----2105-----	-----1667-----	-----1341-----	-----144-----	-----1058-----	

Stations	12	13	14	15	16	17	18	19	20	21	22	23
Taxa												
Siphon.	-----4680-----	-----1394-----		-----1505-----		-----383-----				-----1195-----	-----687-----	145
Chaeto.	3721	21875	34412	10325	30838	10181	19346	19342	3146	49415	12423	9427
Polych.	85	526	1655	212	404	938	2732			199	1461	125
Gastro.	28	368	1220	729	73		3279	4887				4235
Pterop.	7362			94	3524	19469			208	871	158472	25033
Hetero.	210	1568			1175							1498
Cephal.					37	45	55					
Cladoc.				47		45						348
Ostrac.	2945	8451			2350	3438	4263	2912	519	7572	1311	
Mysida.												145
Amphip.	648	1262		706	2496	2635	4809	5719	1084		562	1827
Isopoda												
Euphau.	4454	3364	7144	3622	3781	8306	8635	13622	1497	6376	10238	
Decapo.	141	473			2129	804		3016	229		62	3713
(Cari.)												
Decapo.												
(Brac.)	85	4417	3223	24	4002	3706	273	104	886	15675	1186	116
Copela.	11674			24		2456			733			145
Salpida		789	3572		698	357	2131		122			125

Larvae.

* Includes Stomatopod larvae.

Table 8.--Zooplankton percent standing crops, Deepwater Dumpsite 106,
Albatross IV cruise 74-5

NEUSTON 947

Stations	1	2	3	4	5	6	7	8	9	10	11
Taxa											
Siphonophora											
Chaetognatha	59.5	24.5	0.5	82.5	2.9	33.5	53.2	1.6	52.6	6.8	3.0
Polychaete	2.9		0.7							0.7	
Gastropoda (L)#			0.2							0.7	
Pteropoda	2.3	5	1.2	0.3	2.7						
Heteropoda	1.7	87.2	6.5		42.8						3.0
Cephalopoda											
Cladocera											
Ostracoda						0.4					
Mysidaceae	0.1										
Amphipoda	4.6	5.2	10.2	1.6		2.7	13.5	9.1	3.2	11.6	5.1
Isopoda	2.1	0.5	0.5	0.2	0.3	0.8			12.0	2.0	23.2
Euphausiacea	0.1	4.1	0.2	0.2	61.7	7.4		44.4	28.6	6.8	
Decapoda											
(Caridian) (L)		11.7		0.3	0.3	0.8	19.9	2.8	1.2	8.1	3.0
Decapoda*											
(Brachyura) (L)	31.7	47.4	1.0	3.7	34.6	8.9	13.5	42.2	2.4	63.3	62.6
Copelata											
Salpida											

Stations	12	13	14	15	16	17	18	19	20	21	22	23
Taxa												
Siphonophora				0.4			17.1					
Chaetognatha	4.9	89.6	55.9	90.1	90.5	15.3	68.6	35.2	3.7	15.8	5.1	71.2
Polychaete	1.0	2.0		0.8			1.3				0.1	
Gastropoda (L)#				0.3				0.6			0.1	10.0
Pteropoda	0.7					16.2					6.2	
Heteropoda	1.0	1.6		0.3								
Cephalopoda												
Cladocera												
Ostracoda												
Mysidaceae					0.3							
Amphipoda	9.1	1.0	6.3		0.3	3.2		10.5	3.7	23.3	17.2	2.2
Isopoda	15.7	1.0	2.5			0.9	2.2	0.6	70.4		0.9	21.7
Euphausiacea	2.7	0.3	0.5	0.5	12.6	2.2	32.7	3.7	10.2	15.3		1.3
Decapoda												
(Caridian) (L)	2.7	6.9	4.7	6.8	3.5	2.2	1.8	6.2	0.6	2.3		1.3
Decapoda*												
(Brachyura)	68.5	1.0	24.0	3.2	0.3	26.8	23.3	19.1	6.2	49.9	49.0	2.2
Copelata												
Salpida				0.5		4.4						

Larvae.

* Includes Stomatopod larvae.

Table 8.--Zooplankton percent standing crop (continued)

BONGO 505

Stations	1	2	3	4	5	6	7	8	9	10	11
Taxa											
Siphonophora-----								0.65	--5.18		
Chaetognatha-----	30.69	30.64	45.05	47.33	33.99	59.39	49.63	39.74	73.63	42.95	61.73
Polychaeta-----	4.2	--4.05	--0.21	--1.69	--0.41			1.03	--1.08	--0.57	--3.68
Gastropoda(L)#-----								0.75	--0.54		
Pteropoda-----	39.69	14.46	--2.10	--7.89	17.20	--3.75	--6.81	--9.50		--3.07	--5.08
Heteropoda-----								0.43	--0.38		
Cephalopoda-----	0.08										
Cladocera-----	0.99				1.66						
Ostracoda-----		8.08	--0.28	--5.07	--0.62	--1.54	--0.65	--5.94	--1.51	--1.43	--0.64
Mysidaceae											
Amphipoda-----	0.04	--6.17	--4.03	--4.79	--1.03	--6.14	--2.89	--7.45	--2.47	--5.93	--3.17
Isopoda-----		0.64		0.28		0.34			0.19	--0.41	
Euphausiacea-----	15.43	10.43	43.66	13.52	37.83	23.72	18.47	12.96	13.85	24.34	28.33
Decapoda											
(Caridian)-----	0.30	10.43	--0.28	--4.23		--0.17	--6.71	--0.54	--1.9	--1.02	
Decapoda*											
(Brachyura)-----	10.63	10.85	--2.71	--3.94	--5.91	--3.92	--7.27	--3.89	--3.79	--7.77	--0.84
Copelata-----	0.86		0.28	--7.32	--0.52	--1.02	--1.49	10.48	--0.95	--5.93	
Salpida-----		4.26	--0.07	--3.94	--0.83		3.64	--2.27	--0.76	--3.48	

Stations	12	13	14	15	16	17	18	19	20	21	22	23
Taxa												
Siphon.-----	1.28	--3.15				1.67		0.84		0.45	--2.99	--1.41
Chaeto.-----	38.39	48.20	50.65	50.82	45.78	17.61	36.76	37.71	25.15	30.41	24.93	55.00
Polych.-----	0.19	--0.56	--0.78	--2.33	--0.49	--0.45	--1.35		0.79	--0.09	--0.40	
Gastro.#-----	5.48	--0.45				46.60		0.56			0.40	--0.47
Pterop.-----	12.61	--8.11	--4.65	--7.69	11.36		8.12	10.62	--4.09	38.37	19.14	--9.06
Hetero.-----		0.23								0.09	--0.20	--0.78
Cephal.-----				0.23			0.27	--0.28				
Cladoc.-----										0.36	--1.29	
Ostrac.-----	1.28	--2.82	--4.91	--1.87	--2.43	--3.45	--7.30	--5.59	--1.73	--0.36	--0.90	--0.94
Mysida.												
Amphip.-----	11.15	--2.25	--4.91	--7.69	--7.31	--3.45	12.97	--5.87	11.79	--1.18	--1.49	--7.03
Isopoda-----	0.19		0.26				1.62		0.16			
Euphau.-----	28.34	10.13	15.50	13.29	17.05		12.70	31.00	43.87	--7.15	45.47	23.12
Decapoda												
(Cari.)-----	0.55	--2.25	--1.81	--2.33	--4.87	24.75	--3.78	--2.51	--2.83	--0.36	--0.20	--1.09
Decapoda*												
(Bra.)-----	0.37	--7.88	--8.27	11.65	--9.58	--0.22	10.27	--4.75	--4.40	21.00	--1.79	--0.78
Copelata-----	0.19	11.71	--3.88	--1.17	--0.81		1.35		2.21	--0.09	--1.10	--0.16
Salpida-----		2.14	--4.39	--0.93	--0.32	--1.78	--3.51		2.98	--0.09		--0.16

Larvae.

* Includes Stomatopod larvae.

Table 8.--Zooplankton percent standing crop (continued)

BONGO 333

Stations Taxa	1	2	3	4	5	6	7	8	9	10	11
Siphonophora	----	2.32	-----	3.26	--3.07--	4.49--	4.82--	1.92			
Chaetognatha	----	30.28	34.23	50.66	33.83	46.30	55.37	61.30	38.32	48.00	54.10
Polychaeta	----	6.65	--0.37--	2.52	--1.34--	0.39--	2.31--	1.53--	1.61--	3.04	
Gastropoda	----	7.98	-----	2.82	28.70--	0.99--	0.60--	0.38	-----		6.94
Pteropoda	----		14.23	-----	0.15--	1.59--	7.02--	2.02	12.20--	7.96--	0.15
Heteropoda	----			0.44	-----	0.59--	3.21--	3.17			
Cephalopoda											
Cladocera	----				1.89						
Ostracoda	----	16.47--	1.48	20.65--	0.55--	4.59--	2.51--	5.00	11.70--	4.44	
Mysidaceae	----							0.09			
Amphipoda	----	4.82	12.93	2.37	2.60	4.49	2.61	6.44	4.11	4.56	11.51
Isopoda	----							0.19			
Euphausiacea	----	18.80	35.90	9.50	26.18	15.16	11.45	11.64	10.96	13.58	
Decapoda											
(Caridian)	----		0.09	5.64	-----	0.10--	3.71--	0.48--	0.74--	0.35	26.81
Decapoda*											
(Brachyura)	----	0.33	-----	0.59	--1.66--	4.49--	2.51--	3.08--	6.60--	6.43--	0.47
Copelata	----		0.55	-----		12.17			2.86	8.89	
Salpida	----	12.31	--0.18--	1.48	-----	4.59--	3.81--	2.69--	0.87--	2.69	

Stations Taxa	12	13	14	15	16	17	18	19	20	21	22	23
Siphon.	----	7.80	--2.22--		2.83	-----	0.83	-----		0.49	--1.29--	0.71
Chaeto.	----	40.61	36.49	54.93	65.41	58.17	19.43	42.14	38.83	33.87	20.57	23.32
Polych.	----	0.92	--0.87--	2.64	--1.34--	0.76--	1.79--	5.95	-----	2.14	--0.60--	0.23
Gastro.	----	0.30	--0.61--	1.94	--4.61--	0.13	-----	7.14	9.81	-----		20.97
Pterop.	----	12.28	-----		0.59	--6.64--	37.16	-----	0.41	--9.37--	65.98	47.01
Hetero.	----	0.35	--2.50--		2.21	-----						
Cephal.	----				0.06	--0.08--	0.11	-----				2.81
Cladoc.	----			0.29	-----	0.08	-----					1.72
Ostrac.	----	4.91	13.49	-----	4.43	--6.56--	9.28	--5.84--	5.58	--3.15--	2.46	
Mysida.	----											
Amphip.	----	7.07	--2.10--		4.47	--4.70--	5.03	10.47	11.48	11.67	-----	1.05
Isopoda	----											9.04
Euphau.	----	48.61	--5.61--	11.40	22.94	--7.13--	15.85	18.81	27.34	16.12	--2.65--	19.22
Decapo.												
(Cari.)	----	1.53	--0.78--	-----	4.01	--1.52--	-----	6.05	--2.46--	-----	0.11	18.39
Decapo.*												
(Brac.)	----	0.92	--7.36--	5.14	--0.15--	7.54	--7.07--	0.59	--0.20--	9.54	--6.52--	2.22
Copela.	----	19.47	-----	0.15	-----	4.68	-----		7.89	-----		0.57
Salpida	----	1.31	--5.70--	-----	1.31	--0.68--	4.64	-----	1.31	-----		0.23

Larvae.

* Includes Stomatopod larvae.

Table 9.--Copepod standing crop (number per 1000 m³)/percent standing crop
Deepwater Dumpsite 106, Albatross IV cruise 74-5 BONGO 505

SPECIES	STATIONS																						
	001	002	003	004	005	006	007	008	009	010	011	012	013	014	015	016	017	018	019	020	021	022	023
<i>Rhinocalanus coronatus</i>	1485	15	137	14	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145
<i>Temora stylifera</i>	1485	15	137	14	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145
<i>Temora longicornis</i>	1485	15	137	14	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145
<i>Centropages</i> spp.	1485	15	137	14	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145
<i>Pleurammoma gracilis</i>	1485	15	137	14	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145
<i>Pleurammoma borealis</i>	1485	15	137	14	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145
<i>Pleurammoma robusta</i>	1485	15	137	14	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145
<i>Pleurammoma siphos</i>	1485	15	137	14	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145
<i>Coxycaeus</i> sp.	1485	15	137	14	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145
<i>Orithona</i> spp.	1485	15	137	14	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145
<i>Calanus</i> spp.	1485	15	137	14	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145
<i>Euchrella rostrata</i>	1485	15	137	14	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145
<i>Eucalanus</i> spp.	1485	15	137	14	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145
<i>Acartia longicornis</i>	1485	15	137	14	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145
<i>Sapphirina</i> sp.	1485	15	137	14	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145
<i>Eucapitulus</i> sp.	1485	15	137	14	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145
<i>Euchaeta marina</i>	1485	15	137	14	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145
<i>Ucaideus giesbrechti</i>	1485	15	137	14	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145
<i>Metridia lucens</i>	1485	15	137	14	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145
<i>Sapphirina</i> sp.	1485	15	137	14	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145
<i>Canthocamptus armatus</i>	1485	15	137	14	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145
<i>Aetideus armatus</i>	1485	15	137	14	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145
<i>Heterorhabdus abyssi</i>	1485	15	137	14	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145
Unknown no. 1	1485	15	137	14	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145
Unknown no. 2	1485	15	137	14	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145
Unknown no. 3	1485	15	137	14	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145
<i>Pontella pennata</i>	1485	15	137	14	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145
<i>Chirocentrus</i> sp.	1485	15	137	14	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145
<i>Undinopsis bradyi</i>	1485	15	137	14	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145

Species no. 4, ♀ *Pseudocyclops* sp., ♂ *Pseudocyclops* sp., ♂ *Ucaideus* sp.

Table 9.--Copepod standing crop (number per 1000 m³)/percent standing crop
Deepwater Dumpsite 106, Albatross IV cruise 74-5 BONGO 333

SPECIES	001	002	003	004	005	006	007	008	009	010	011	012	013	014	015	016	017	018	019	020	021	022	023
<i>Rhincalanus coronatus</i>	7653	7330	7497	7549	7549	7549	7549	7549	7549	7549	7549	7549	7549	7549	7549	7549	7549	7549	7549	7549	7549	7549	7549
<i>Temora stylifera</i>	368	10	471	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
<i>Temora longicornis</i>	2360	0.6	541	0.5	450	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
<i>Centropages</i> spp.	5003	2054	2253	2643	2643	2643	2643	2643	2643	2643	2643	2643	2643	2643	2643	2643	2643	2643	2643	2643	2643	2643	2643
<i>Pleuromamma gracilis</i>	102	54	48.0	113	35.5	33.7	7.9	3443	4432	3.9	1779	13.5	1033	1033	1033	1033	1033	1033	1033	1033	1033	1033	1033
<i>Pleuromamma borealis</i>	1708	0.5	1708	0.5	1708	0.5	1708	0.5	1708	0.5	1708	0.5	1708	0.5	1708	0.5	1708	0.5	1708	0.5	1708	0.5	1708
<i>Pleuromamma robusta</i>	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708
<i>Pleuromamma xiphias</i>	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708
<i>Corycaeus</i> sp.	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708
<i>Oithona</i> spp.	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708
<i>Calanus</i> spp.	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708
<i>Euchirella rostrata</i>	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708
<i>Eucalanus</i> spp.	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708
<i>Acartia longicornis</i>	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708
<i>Sapphirina</i> sp.	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708
<i>Eucaerophorus</i> sp.	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708
<i>Eucaerella marina</i>	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708
<i>Oncaea</i> sp.	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708
<i>Metridia lucens</i>	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708
<i>Sapphirina</i> sp.	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708
<i>Candacia armata</i>	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708
<i>Aethideus armatus</i>	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708
<i>Heterorhabdus abyssalis</i>	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708
Unknown no. 1	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708
Unknown no. 2	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708
Unknown no. 3	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708
<i>Pseudocricoides</i> sp.	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708
<i>Faroeella</i> sp.	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708
<i>Ucaideus giesbrechti</i>	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708	2.5	1708

Table 10.--Pteropod standing crop (number per 1000 m³)/percent standing crop
Deepwater Dumpsite 106, Albatross IV cruise 74-5 NEUSTON 947

SPECIES	001	002	003	004	005	006	007	008	009	010	011	012
<i>Limacina trochiformis</i>												
<i>Limacina retroversa</i>												
<i>Limacina inflata</i>												
<i>Limacina helicina</i>												
<i>Limacina</i> sp. (juveniles)												
<i>Cresis virgula conica</i>				10 66	52 100							
<i>Styliola subula</i>								2 40				
<i>Diachia triaspinea</i>												
<i>Clio cuspidata</i>												
<i>Clio pyramidata</i>												
<i>Cavolina uncinata</i>			20 100			14 66		2 40				
<i>Cavolina inflexa</i>				5 33		7 33						
<i>Cavolina longirostris</i>								1 20				

Table 10.---Pteropod standing crop (number per 1000 m³)/percent standing crop
Deepwater Dumpsite 106, Albatross IV cruise 74-5 BONGO 505

Stations 1 to 12

SPECIES	001	002	003	004	005	006	007	008	009	010	011	012
<i>Limacina trochiformis</i>	250 6				6			2056				2
<i>Limacina retroversa</i>	80 2	170 25	1680 100	40 5	309 5	40 20	160 13	1254 32	434 42		119 12	1.6 1003
<i>Limacina inflata</i>		40 6		40 5				100 3	43 4	146 25		2 1.6
<i>Limacina helicina</i>		20 3		40 5	155 2	40 20		100 3				4 3
<i>Limacina</i> sp. (juveniles)	3510 91	440 62		750 85	5677 92	140 60	1060 87		564 54	438 75	836 88	2420 56
<i>Cresis virgula conica</i>												
<i>Styliola subula</i>												
<i>Dicaria trispinosa</i>												
<i>Clio cuspidata</i>								100 3				
<i>Clio pyramidata</i>								3 1.5				2 1.6
<i>Cavolina uncinata</i>	20 3											
<i>Cavolina inflexa</i>								50 1.5				
<i>Cavolina longirostris</i>												

Table 10.--Pteropod standing crop (number per 1000 m³)/percent standing crop
Deepwater Dumpsite 106, Albatross IV cruise 74-5 BONGO 505
Stations 13 to 23

SPECIES	013	014	015	016	017	018	019	020	021	022	023
<i>Limacina trochiformis</i>						1835 89	277 9	126 100			
<i>Limacina retroversa</i>	658 36	90 33	366 57	1120 64					4491 44	240 15	44 4
<i>Limacina inflata</i>	110 6					108 5.3					14 1
<i>Limacina helicina</i>	219 12			39 2		108 5.3	2678 87.8				
<i>Limacina</i> sp. (juveniles)	712 39	180 67	268 42	657 38					5614 56	1315 83	860 93
<i>Cresis virgula conica</i>											
<i>Styliola subula</i>	82 45									32 2	
<i>Diacria trispinosa</i>											
<i>Clio cuspidata</i>											
<i>Clio pyramidata</i>											
<i>Cavolina uncinata</i>						108 5.3					
<i>Cavolina inflexa</i>	55 3						92 3				
<i>Cavolina longirostris</i>											

Table 10.--Pteropod standing crop (number per 1000 m³)/percent standing crop
Deepwater Dumpsite 106, Albatross IV cruise 74-5 BONGO 303
Stations 1 to 12

SPECIES	001	002	003	004	005	006	007	008	009	010	011	012
<i>Limacina trochiformis</i>						91 33						
<i>Limacina retroversa</i>			1542 21				43 7	671 64	88 6	459 32		
<i>Limacina inflata</i>						91 33						
<i>Limacina helicina</i>			1735 23						555 38	229 16		
<i>Limacina</i> sp. (juveniles)			4240 56				307 50		802 56	736 52		
<i>Cresis virgula conica</i>						91 33	219 35	230 23				
<i>Styliola subula</i>								40 7				
<i>Diacria trispinosa</i>												
<i>Clio cuspidata</i>								40 7				
<i>Clio pyramidata</i>												
<i>Cavolina uncinata</i>												
<i>Cavolina inflexa</i>												
<i>Cavolina longirostris</i>							44 7	40 7				

Table 10.--Pteropod standing crop (number per 1000 m³)/percent standing crop
Deepwater Dumpsite 106, Albatross IV cruise 74-5 BONGO 303
Stations 13 to 23

SPECIES	013	014	015	016	017	018	019	020	021	022	023
<i>Limacina trochiformis</i>											
<i>Limacina retroversa</i>	789 18				2234 50				3850 15	374 7	
<i>Limacina inflata</i>					89 2						
<i>Limacina helicina</i>	2105 49				849 19			61 27	12215 46		1594 58
<i>Limacina</i> sp. (juveniles)	1210 28			404 78	1296 29			167 73	10489 39	4690 91	1154 42
<i>Cresis virgula conica</i>		260 100									
<i>Styliola subula</i>	210 4										
<i>Diocria trispinosa</i>							2 6.5				
<i>Clio cuspidata</i>										6 2	
<i>Clio pyramidata</i>							44 90			1 1	
<i>Cavolina uncinata</i>				36 7							
<i>Cavolina inflexa</i>				72 14			1 3.5				
<i>Cavolina longirostris</i>											

Table 11.--Macroplankton and nekton (excluding fish) removed prior to splitting, Deepwater Dumpsite 106, Albatross IV cruise 74-5

NEUSTON 947

<u>Station</u>	<u>Taxa</u>	<u>Number</u>	<u>Standing Crop</u> <u>(#/1000m²)</u>
1	Cephalopoda: Decapoda	1	0.3
2	Cephalopoda: Octopoda	2	0.8
	<i>Argonauta argo</i>		
4	Siphonophora: <i>Physalia pelagica</i>	3	0.9
12	Macrura: phyllosoma larva	1	0.4
14	Siphonophora: <i>Physalia pelagica</i>	1	0.3
16	Siphonophora: <i>Physalia pelagica</i>	2	0.8
17	Stomatopoda: <i>Erichthus</i> larvae	4	1.3

BONGO 505

<u>Station</u>	<u>Taxa</u>	<u>Number</u>	<u>Standing Crop</u> <u>(#/1000m³)</u>
3	Heteropoda	1	6.2
	Cephalopoda: Decapoda	1	6.2
4	Cephalopoda: Decapoda	1	2.8
6	Cephalopoda: Decapoda	1	3.0
8	Cephalopoda: Octopoda	1	3.1
14	Cephalopoda: Decapoda	1	2.8
17	Cephalopoda: Decapoda	1	2.8
18	Cephalopoda: Decapoda	3	5.1
	Octopoda	1	1.7
19	Cephalopoda: Decapoda	2	2.9

BONGO 333

<u>Station</u>	<u>Taxa</u>	<u>Number</u>	<u>Standing Crop</u> <u>(#/1000m³)</u>
3	Cephalopoda: Decapoda	1	6.0
7	Cephalopoda: Decapoda	1	2.7
14	Cephalopoda: Decapoda	1	2.7
	Octopoda	1	2.7
16	Cephalopoda: Decapoda	1	2.3
17	Cephalopoda: Octopoda	1	2.8
19	Cephalopoda: Decapoda	1	1.6
22	Cephalopoda: Decapoda	1	2.0

Table 12.--Euphauslid standing crop and percent standing crops
Deepwater Dumpsite 106, Albatross IV cruise 74-5

NEUSTON 947--Standing crop (number per 1000 m²)

Species	STATIONS											
	1	2	3	4	5	6	7	8	9	10	11	12
Nyctiphanes couchii	-	-	-	-	2932 24%	14 10%	-	-	-	-	-	-
Stylocheiron robustum	-	-	-	-	785 6%	78 57%	-	-	78 77%	82 70%	-	-
*Damaged	-	-	10	5	8692 70%	43 31%	-	-	22 23%	35 30%	-	-
Sample Missing	15	92	-	-	-	-	-	6211 100%	-	-	-	-

337

Species	STATIONS											
	13	14	15	16	17	18	19	20	21	22	23	
Nyctiphanes couchii	-	-	-	-	98 44%	-	345 56%	-	21 4%	44 25%	-	
Stylocheiron robustum	-	3 100%	-	-	26 12%	-	35 6%	-	295 64%	31 18%	-	
*Damaged	8 100%	-	3 100%	12 100%	97 44%	5 100%	230 38%	2 100%	130 28%	96 56%	4 100%	
Sample Missing	-	-	-	-	-	-	-	-	-	-	-	

*Specimens which lost recognizable characteristics for identification.

Table 12 (continued)

BONGO 505--Standing crop (number per 1000 m³)

Species	STATIONS											
	1	2	3	4	5	6	7	8	9	10	11	12
<i>Nyctiphanes couchii</i>	3033 20%	114 11%	15286 48%	2098 97%	10379 80%	-	1108 28%	5169 86%	-	1156 20%	-	-
<i>Stylocheiron elongatum</i>	5730 38%	-	-	45 3%	-	5076 77%	-	-	-	-	-	-
<i>Thysanoessa raschii</i>	562 4%	-	-	-	-	-	1464 37%	-	902 57%	-	-	-
<i>Thysanoessa longicaudata</i>	-	-	-	-	-	-	-	-	-	-	-	-
<i>Euphausia americana</i>	-	-	-	-	-	-	-	-	-	-	1161 29%	915 20%
*Damaged	5730 38%	966 89%	15923 52%	-	2595 20%	1516 23%	1386 35%	841 14%	680 43%	4626 80%	2841 71%	3523 77%

Species	STATIONS											
	13	14	15	16	17	18	19	20	21	22	23	
<i>Nyctiphanes couchii</i>	1504 61%	2976 55%	-	2190 54%	-	-	1947 19%	483 11%	1717 31%	1900 26%	23	
<i>Stylocheiron elongatum</i>	-	-	-	-	-	1318 26%	-	-	-	1315 18%	-	
<i>Thysanoessa raschii</i>	-	-	-	-	-	304 6%	-	-	-	-	-	
<i>Thysanoessa longicaudata</i>	-	-	-	365 9%	-	-	-	-	-	-	-	
<i>Euphausia americana</i>	-	-	1333 96%	-	-	-	-	-	-	-	-	
*Damaged	962 39%	2435 45%	56 4%	1500 37%	-	3948 68%	8302 81%	3912 89%	3822 69%	4092 56%	2196 100%	

*Specimens which lost record

*Specimens which lost recognizable characteristics for species identification.

Table 12 (continued)

BONGO 303--Standing crop (number per 1000 m³)

Species	STATIONS											
	1	2	3	4	5	6	7	8	9	10	11	12
<i>Nyctiphanes couchii</i>	-	-	-	1067	-	-	2751	1971	-	-	-	2450
				34%			55%	34%				55%
<i>Stylocheiron elongatum</i>	1636	10105	17439	752	51%	-	600	2318	-	-	-	356
	34%	19%	24%				12%	40%				8%
<i>Euphausia americana</i>	2455	51%	-	-	-	2712	150	580	850	-	-	134
						39%	3%	10%	47%			3%
<i>Thysanopoda aequalis</i>	-	-	-	-	-	-	-	-	-	747	-	-
										14%		-
*Damaged	722	43077	1317	16755	4293	1500	927	958	4587	-	-	1514
	15%	81%	42%	49%	61%	30%	16%	53%	86%	-	-	34%

Species	STATIONS											
	13	14	15	16	17	18	19	20	21	22	23	
<i>Nyctiphanes couchii</i>	-	3286 46%	797 22%	2042 54%	1495 18%	4922 57%	3678 27%	389 26%	1658 26%	3993 39%	-	
<i>Stylocheiron elongatum</i>	-	1715 24%	1666 46%	1096 29%	-	1727 20%	5040 37%	-	2742 43%	819 8%	-	
<i>Euphausia americana</i>	2423 72%	-	217 6%	76 2%	-	-	-	-	-	-	-	
<i>Thysanopoda aequalis</i>	-	-	-	-	-	-	-	-	-	-	-	
*Damaged	942 28%	2143 30%	942 26%	567 15%	6811 82%	1986 23%	4904 36%	1108 74%	1976 31%	5426 53%	-	

*Specimens which lost recognizable characteristics for identification.

1991

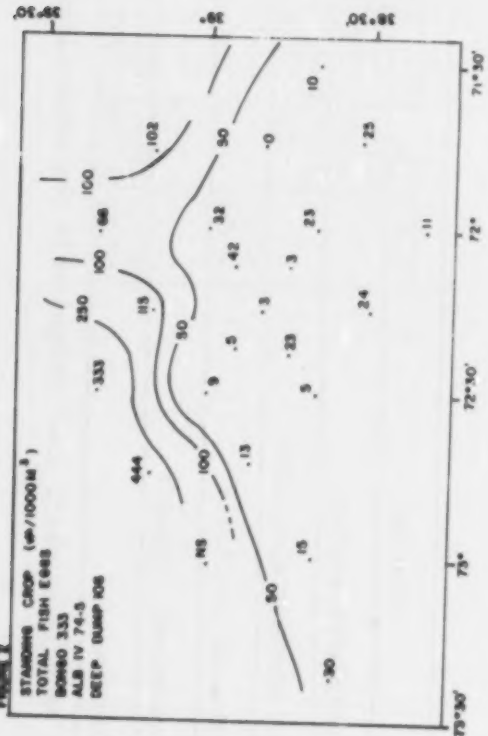


FIGURE 3

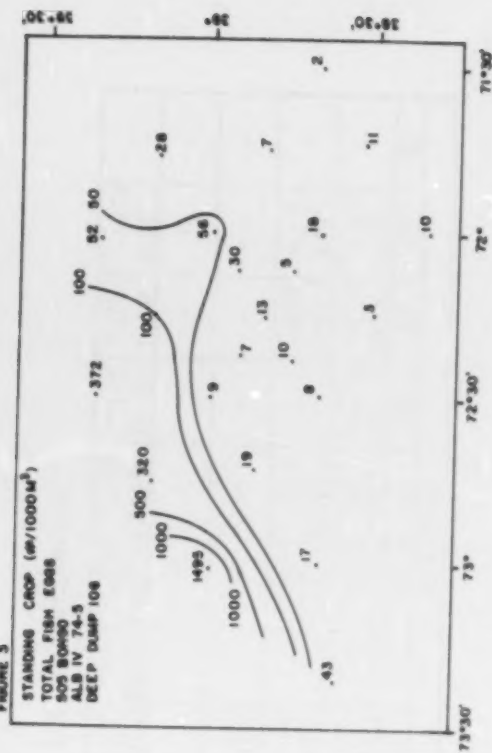


FIGURE 4

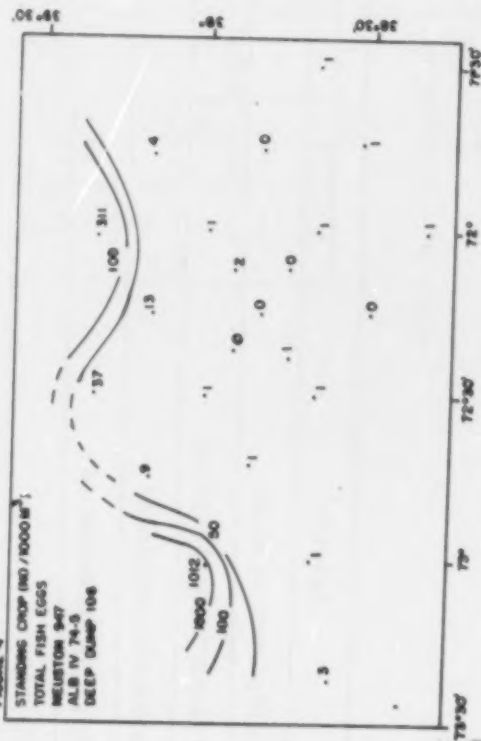
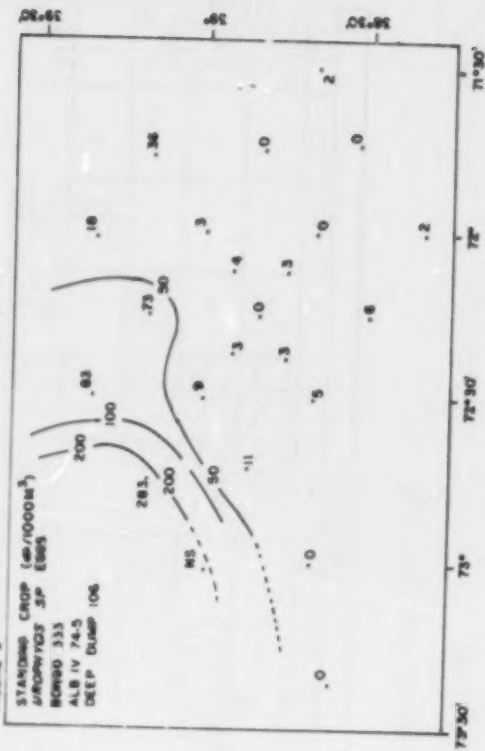
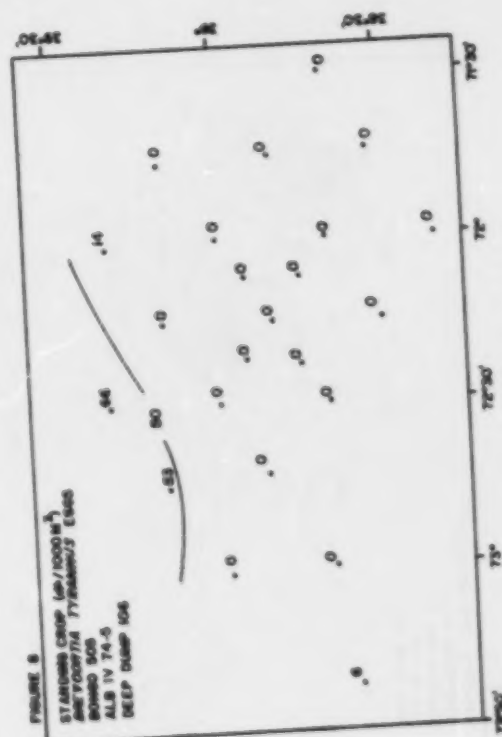
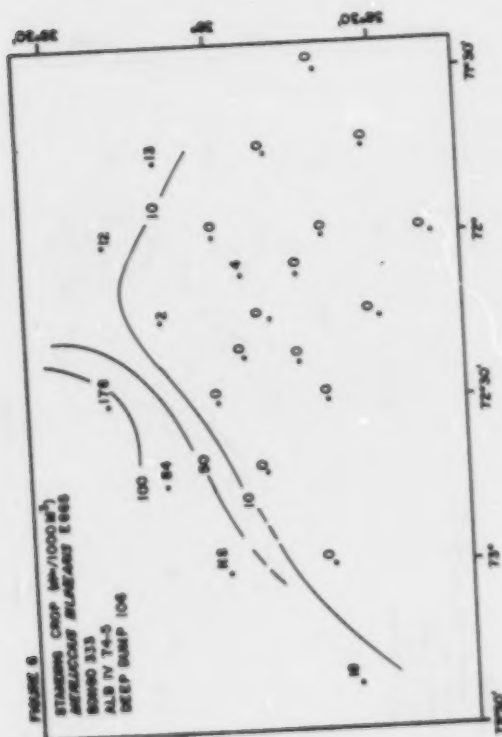
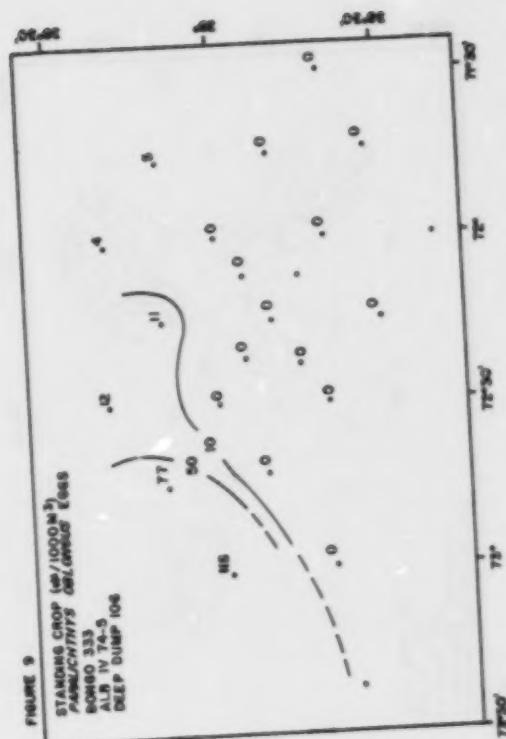
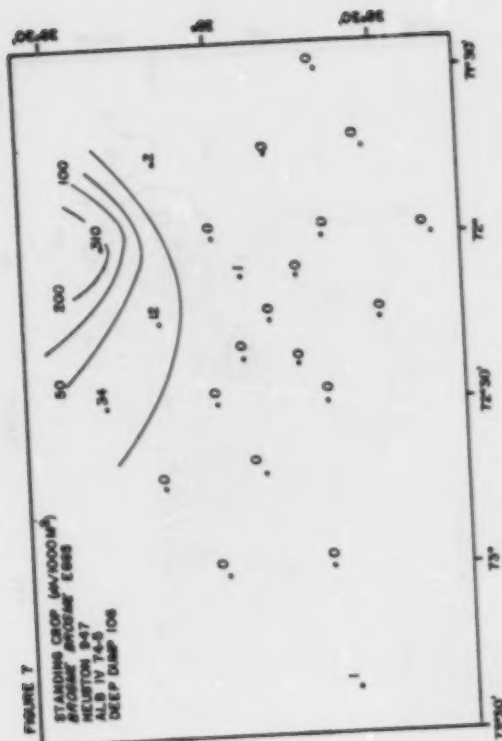
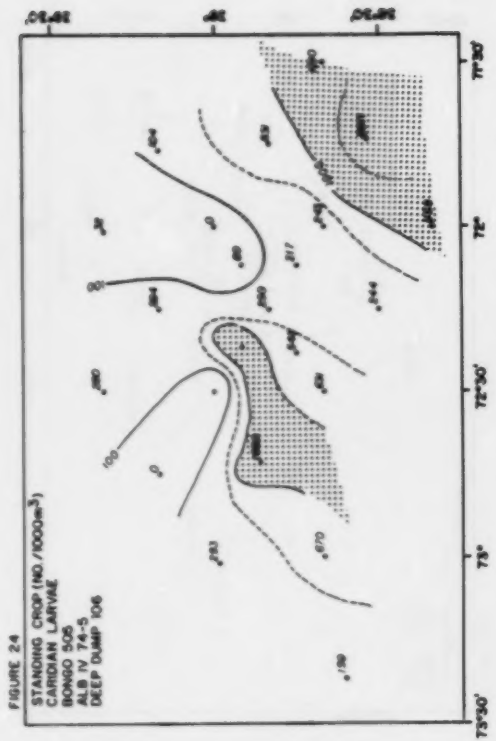
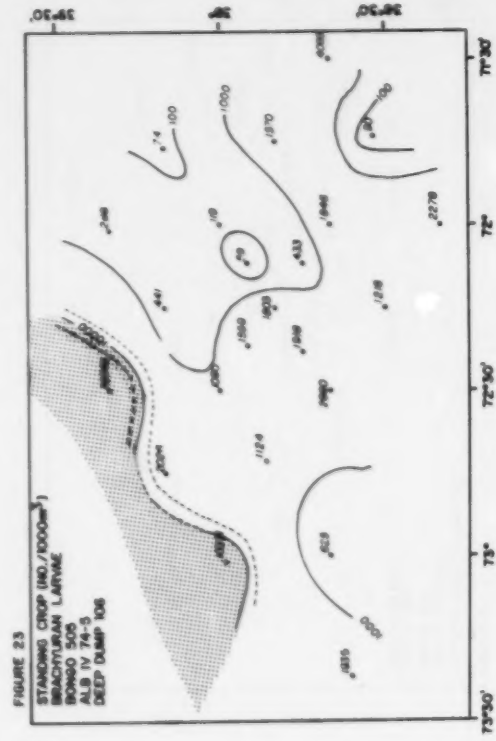
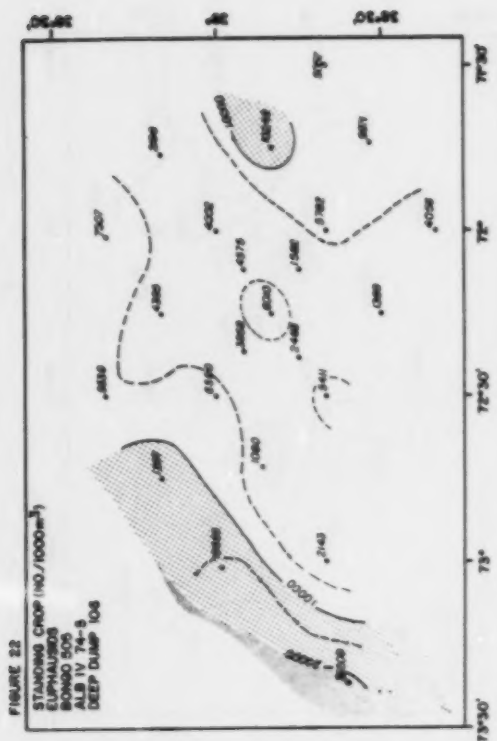
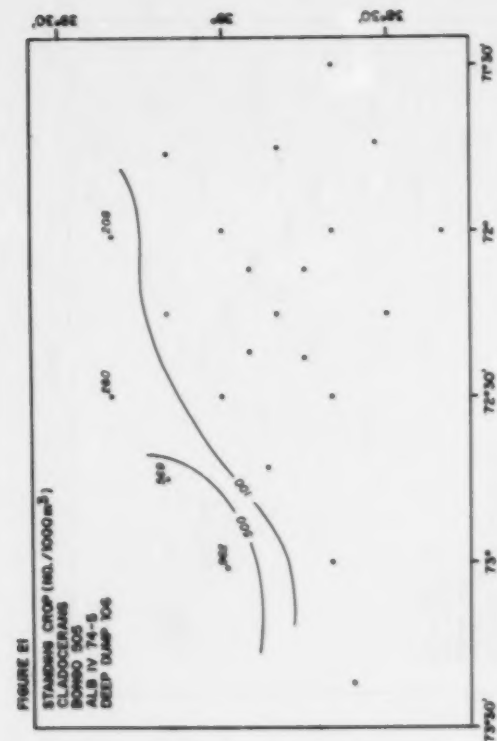


FIGURE 5







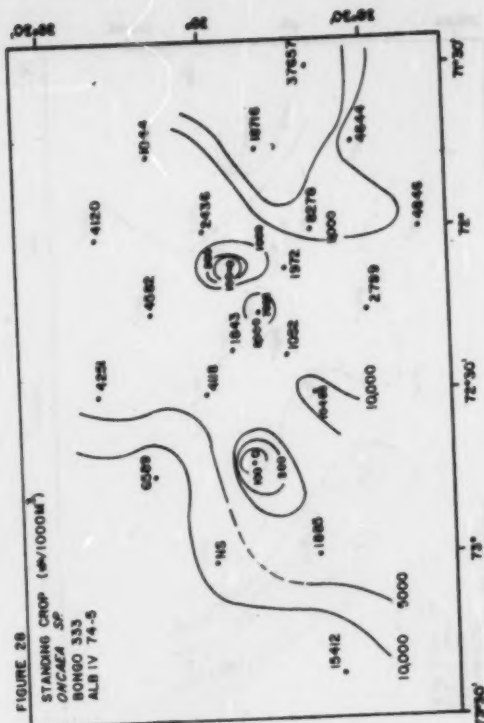
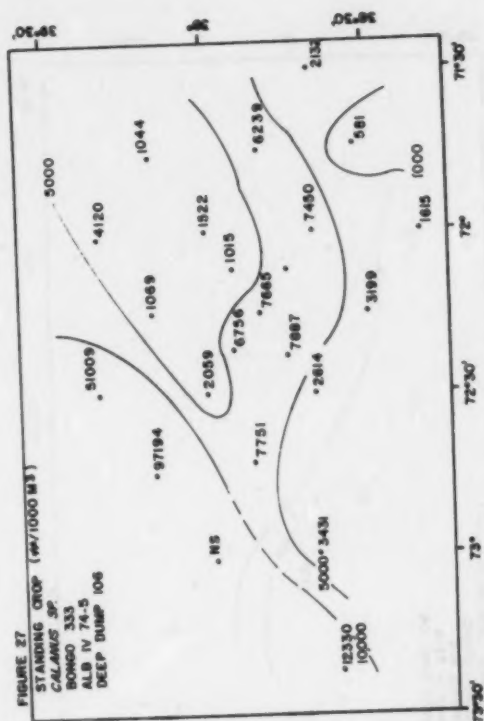
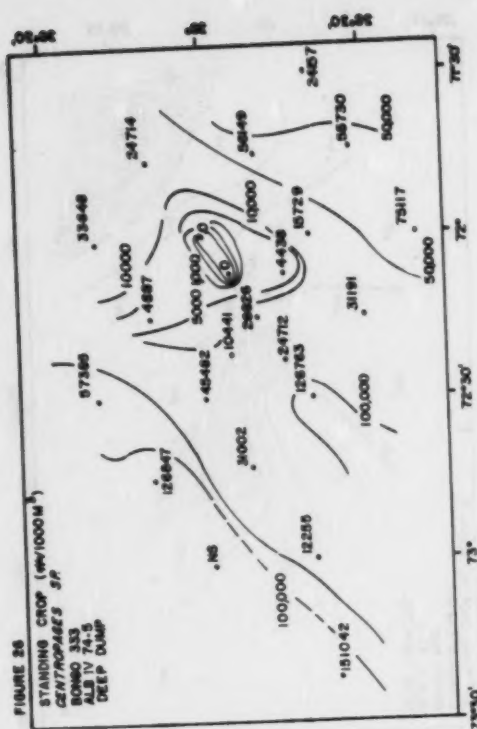
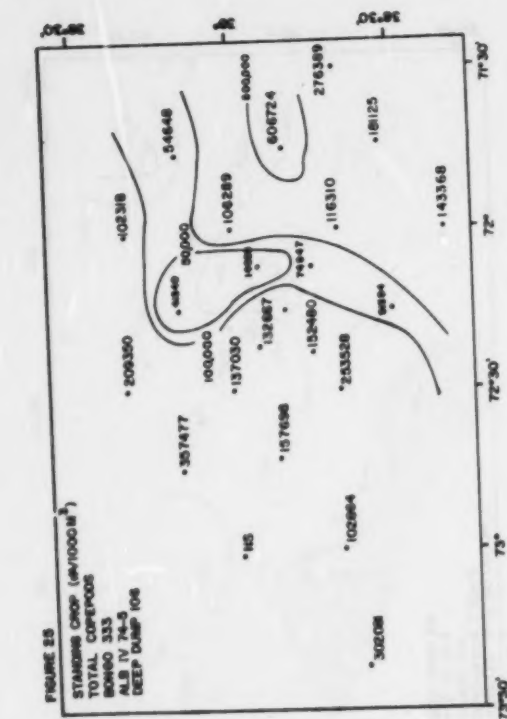


FIGURE 33
STANDING CROP (g/1000m²)
EUCHIRELLA ROSTRATA
BOMBO 500
ALB IV 74-5
DEEP DUMP 106

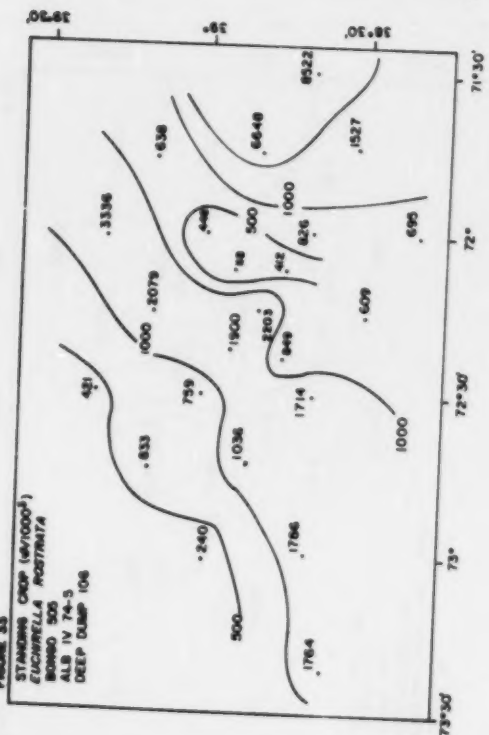


FIGURE 34
STANDING CROP (g/1000m²)
AMMOCALANUS CONCOMITANS
BOMBO 500
ALB IV 74-5
DEEP DUMP 106

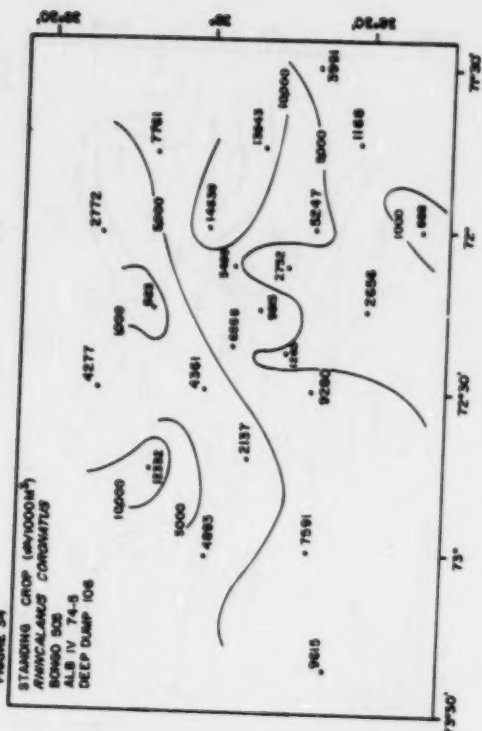
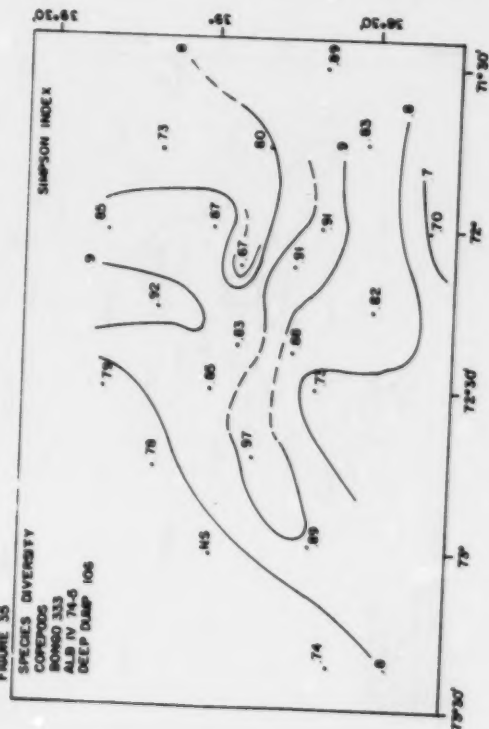


FIGURE 35
SPECIES DIVERSITY
COREPODS
BOMBO 500
ALB IV 74-5
DEEP DUMP 106



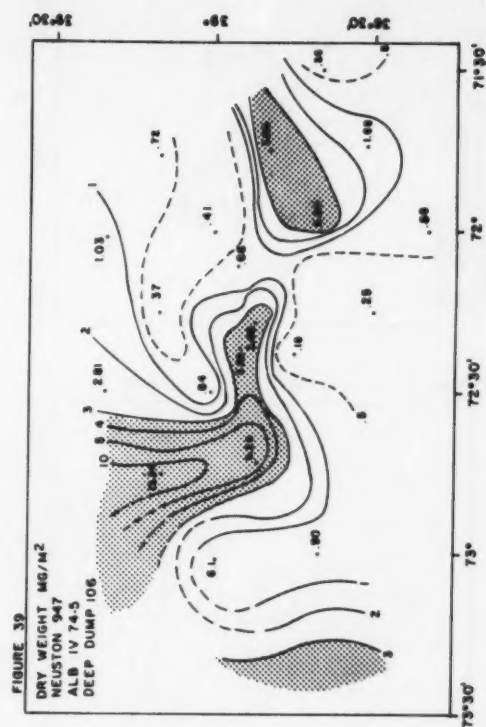
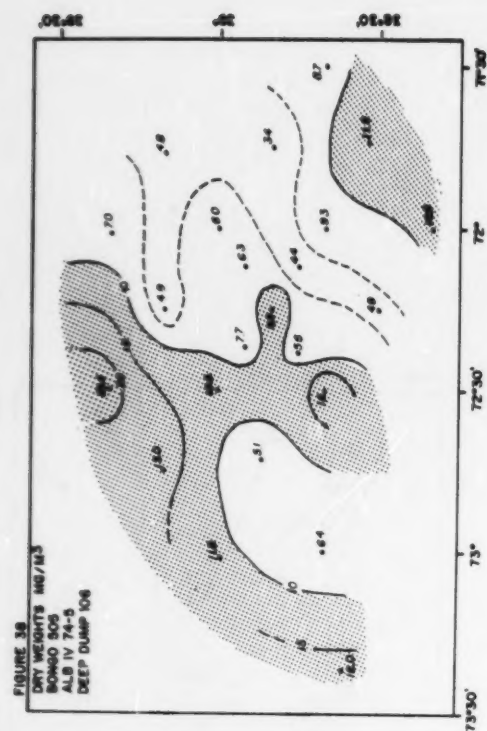
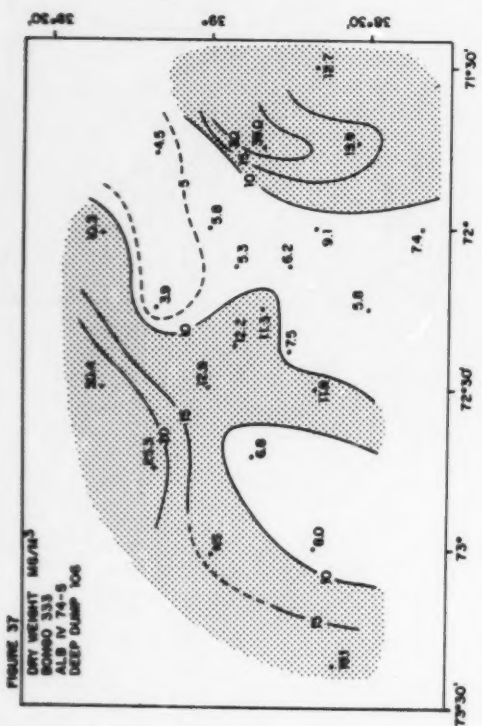


FIGURE 40
SURFACE DENSITY (σ_t)
ALB IV 74-5
DEEP DUMP 106

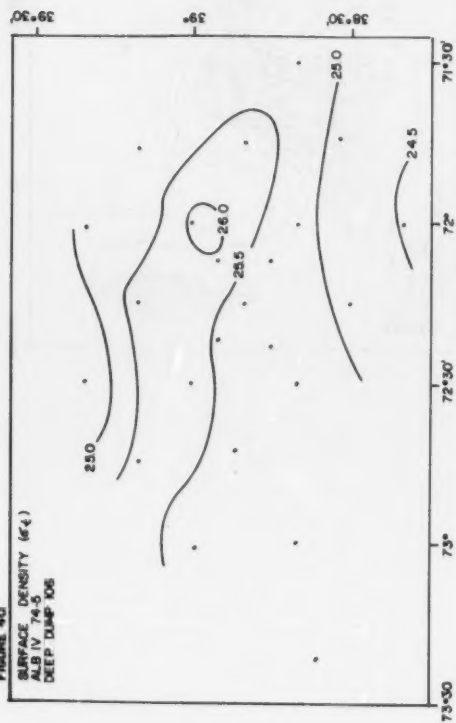


FIGURE 41
SEA SURFACE SALINITY ‰
ALB IV 74-5
DEEP DUMP 106

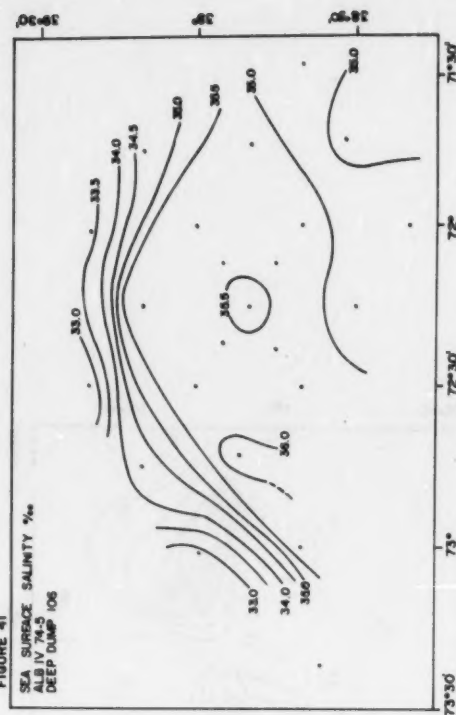
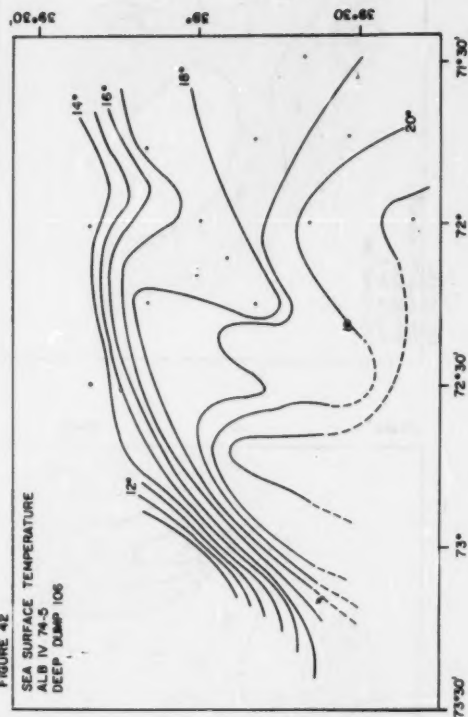
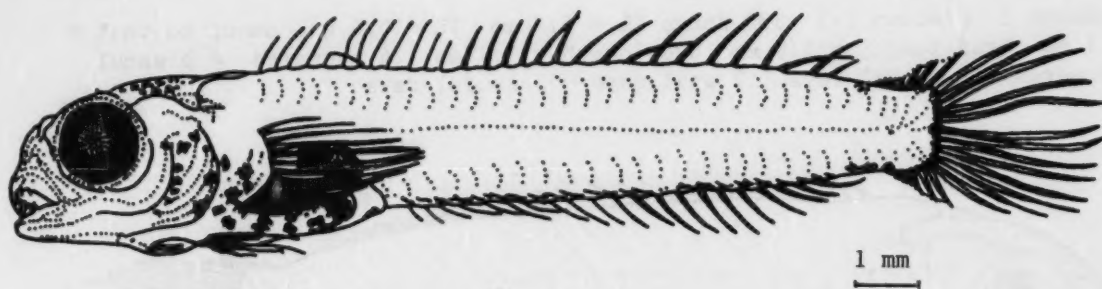


FIGURE 42
SEA SURFACE TEMPERATURE
ALB IV 74-5
DEEP DUMP 106

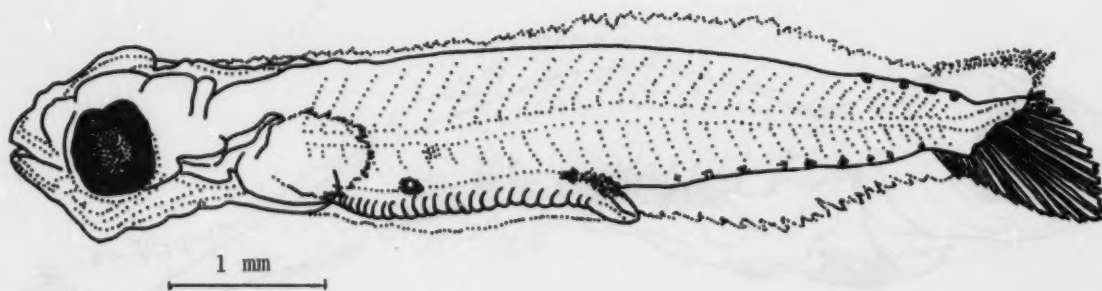


APPENDIX A.--Sketches of unknown fish larvae.

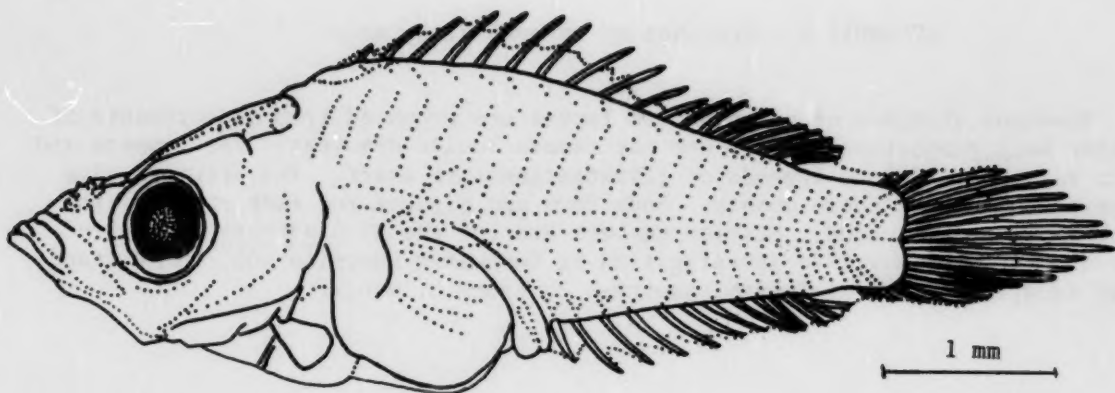
Freehand sketches of unknown fish larvae are prepared from measurements of major body proportions. They are not camera lucida drawings. The myomere and fin ray counts in the legends of illustrations are exact. The drawings give approximations of these counts. Body form and pigment for each species are accurately represented. Station numbers are for the RV Albatross IV cruise 74-5 during the May 1974 investigation of Deepwater Dumpsite 106. SL = standard length; TL = total length. Sketches by Bruce C. Mundy.



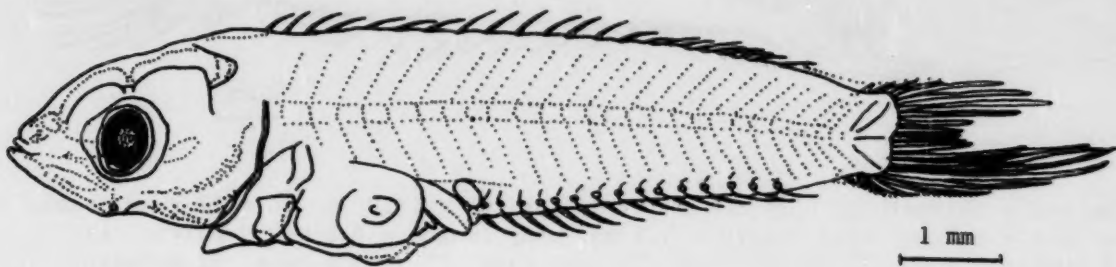
Unknown A (Biennioid) Station 1-1 Neuston SL = 15.2 mm TL = 17.9 mm snout to vent = 6.0 mm head length = 3.3 mm body length = 2.6 mm 5 pelvic rays 14 pectoral rays 29 dorsal rays 21 anal rays 25 caudal rays 32 myomeres 7 preanal myomeres



Unknown D Station 12-1 333 Bongo SL = 6.7 mm TL = 7.2 mm Snout to vent = 4.05 mm Body depth = 1.01 mm head length = 1.02 mm 32 myomeres 21 formed caudal rays



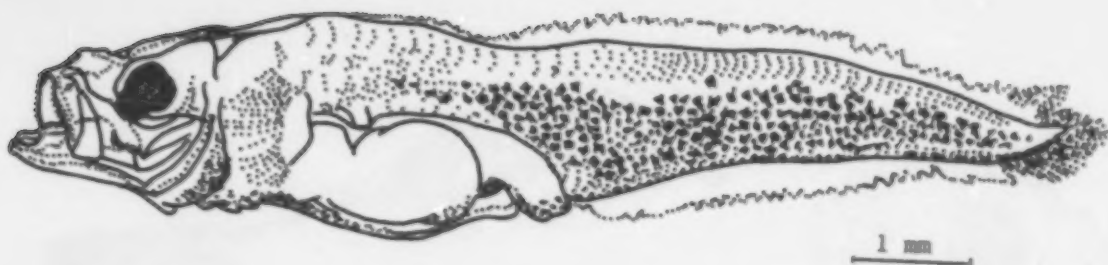
Unknown E Station 7-1 333 Bongo SL = 5.2 mm TL = 6.4 mm snout to vent = 3.1 mm head length = 1.9 mm body depth = 1.7 mm 24 myomeres 8 preanal myomeres 19 dorsal rays 12 anal rays 22 caudal rays



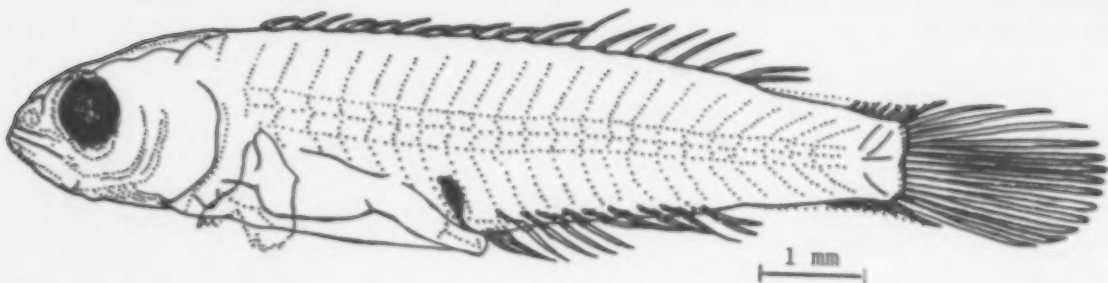
Unknown H Station 9-1 505 Bongo SL = 8.5 mm TL = 10.6 mm Snout to vent = 4.1 mm head length = 2.2 mm body depth = 2.1 mm 23 myomeres 5 preanal myomeres 23 dorsal rays 15 anal rays 23 caudal rays



Unknown J Station 9-1 Bongo 333 SL = 3.3 mm TL = 3.6 mm Snout to vent = 2.0 mm head length = 9 mm Body depth = .6 mm 17 preanal myomeres 30 myomeres



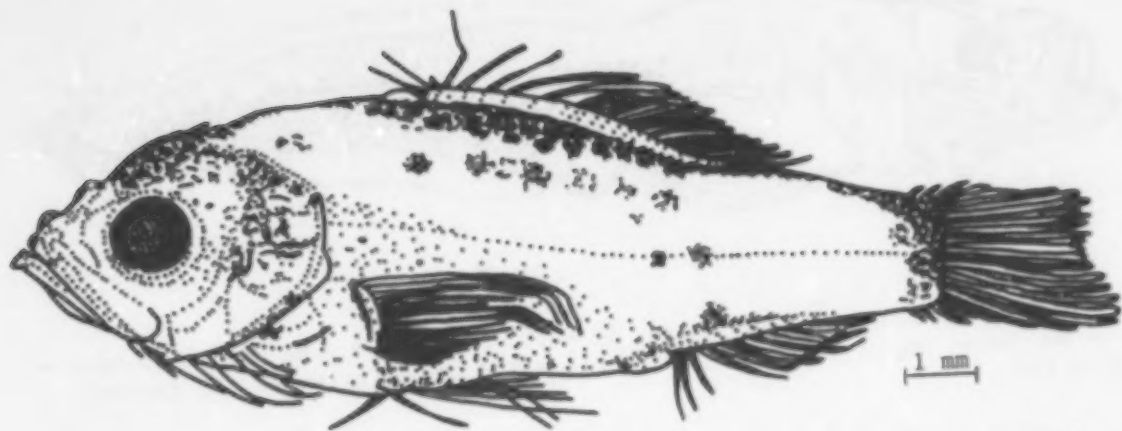
Unknown K Station 10-1 505 Bongo SL = 9.0 mm TL = 9.3 mm Snout to vent = 4.4 mm head length = 2.3 mm body depth = 1.8 mm 51 myomeres 15 preanal myomeres



Unknown L Station 10-1 505 Bongo SL = 8.6 mm TL = 10.5 mm Snout to vent = 4.4 mm head length = 2.0 mm body depth = 2.0 mm 22 myomeres 9 preanal myomeres 9 dorsal spines 10 rays 4 anal spines 8 anal rays 27 caudal rays



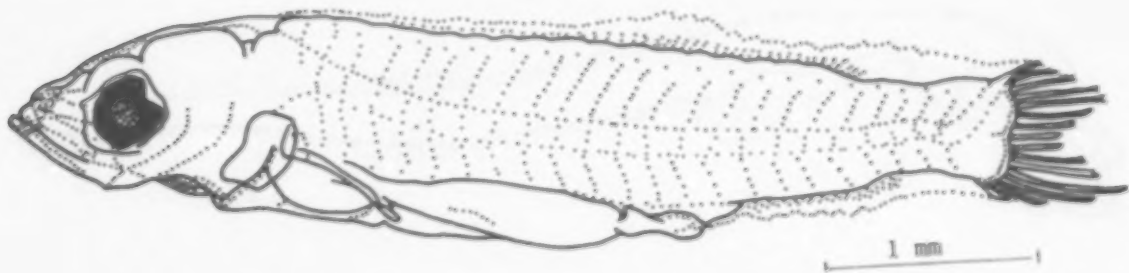
Unknown M Station 18-1 333 Bongo SL = 12.9 mm TL = 13.1 mm Snout to vent = 4.5 mm head length = 2.0 mm body depth = 1.4 mm myomeres not apparent



Unknown N Station 19-1 333 Bongo SL = 14.5 mm TL = 17.2 mm Snout to vent = 10.0 mm head length = 4.5 mm body depth = 4.6 mm 9 pelvic rays 3 anal spines 6 anal rays 15 dorsal rays 4 dorsal spines 17 pectoral rays 26 caudal rays



Unknown O Station 15-1 505 Bongo SL = 4.6 mm TL = 4.8 mm Snout to vent = 2.8 mm head length = 1.1 mm body depth = .7 mm 32 myomeres 15 preanal myomeres



Unknown P Station 16-1 505 Bongo SL 4.7 mm TL = 5.2 mm Snout to vent = 3.4 mm head length = 1.0 mm body depth = .9 mm 15 caudal rays developed 24 myomeres



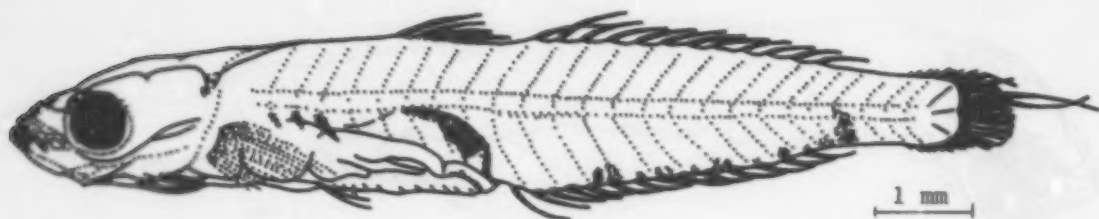
Unknown Q Station 19-1 505 Bongo SL = 5.9 mm TL = 6.0 mm Snout to vent = 4.3 mm head length = 1.1 mm body depth = 1.0 mm 26 preanal myomeres 38 myomeres



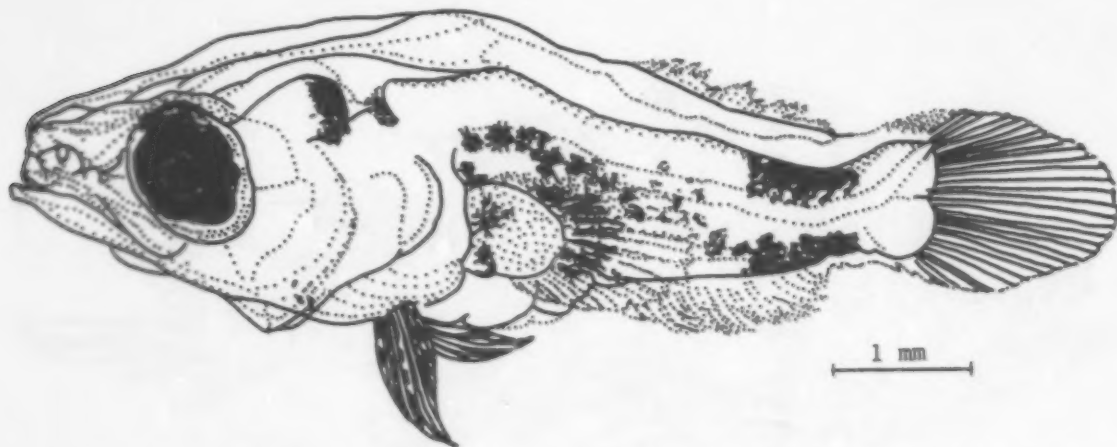
Unknown R Station 20-1 505 Bongo SL = 9.1 mm TL = 11.1 mm snout to vent = 5.2 mm head length = 3.5 mm body depth = 3.6 mm 16 pectoral rays 10 dorsal rays 28 caudal rays 15 anal rays 4 pelvic rays 2 dorsal spines



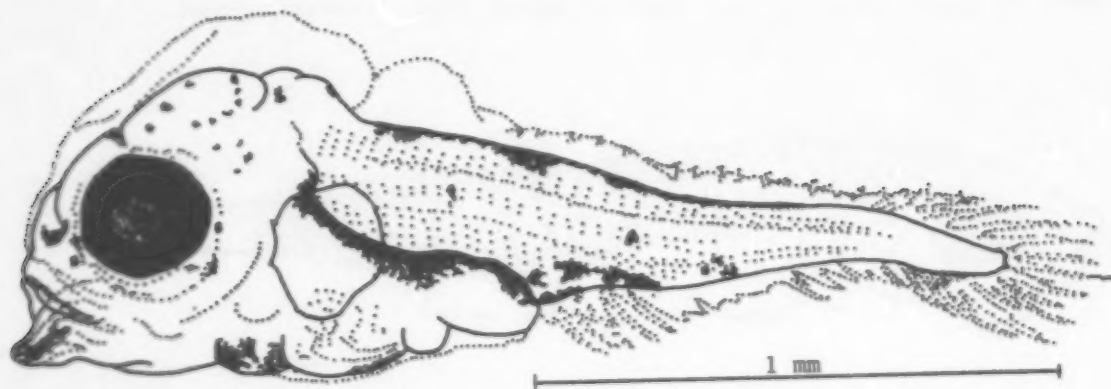
Unknown S Station 2-1 333 Bongo SL = 3.6 mm TL = 3.8 mm Snout to vent = 2.4 mm head length = .9 mm body depth = .5 mm



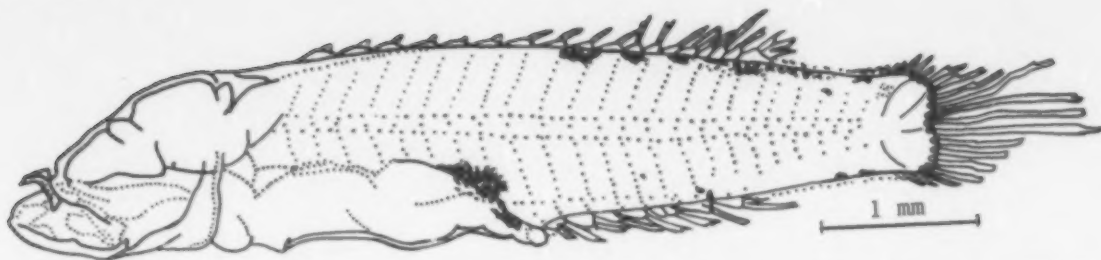
Unknown T Station 5-1 333 Bongo SL = 10.1 mm TL = 11.6 mm Snout to vent = 5.2 mm body depth = 1.6 mm head length = 2.2 mm 24 myomeres 8 preanal myomeres 4 dorsal spines 12 dorsal rays 13 anal rays 2 pelvic rays ? pectoral rays 29 caudal rays



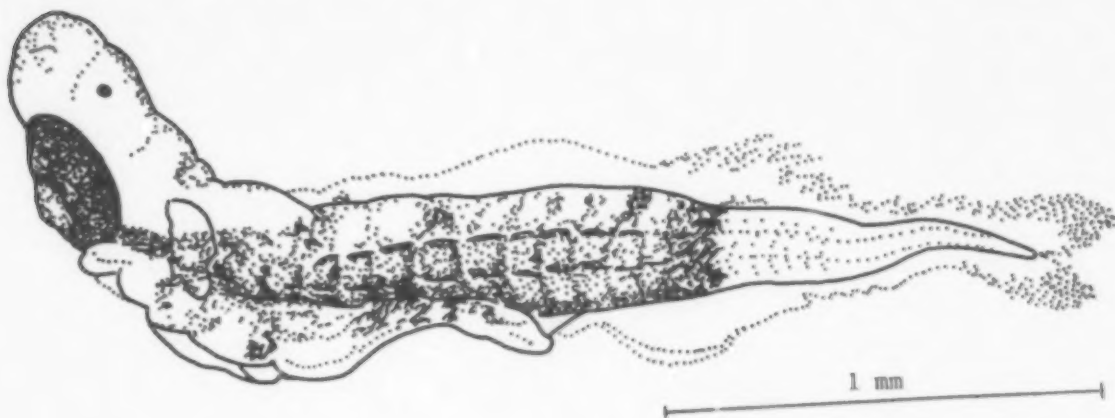
Unknown V Station 13-1 333 Bongo SL = 6.7 mm TL = 8.0 mm Snout to vent = 4.2 mm head length = 2.5 mm body depth = 2.2 mm 7 pelvic rays 18 formed caudal rays no formed dorsal or anal rays myomeres not visible 20? pectoral rays



Unknown W Station 13-1 333 Bongo SL = 1.9 mm TL = 2.1 mm Snout to vent = 1.0 mm head length = .5 mm body depth = .6 mm 48 myomeres



Unknown X Station 18-1 333 Bongo SL = 5.9 mm TL = 6.7 mm Snout to vent = 3.3 mm head length = 1.2 mm body depth = 1.3 mm 11 dorsal spines 7 rays 7 anal rays 21 caudal rays 22 myomeres 9 preanal myomeres



Unknown Y Station 18-1 333 Bongo SL = 2.4 mm TL = 2.5 mm Snout to vent = 1.3 mm head length = ? body depth = .5 mm 22 formed myomeres 7 preanal myomeres



Unknown Z Station 18-1 333 Bongo SL = 3.4 mm TL = 4.3 mm Snout to vent = 2.2 mm head = 1.0 mm body depth = 1.1 mm

SYSTEMATIC ANALYSIS OF MIDWATER FISHES OBTAINED AT
DEEPWATER DUMPSITE 106 MAY 1974¹

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ABSTRACT

Ten oblique tows of a 10-foot (3.09-m) Isaacs-Kidd midwater trawl at Deepwater Dumpsite 106 produced 4,029 specimens having a total volume of 2,523 ml. These represent 114 species in 30 families. Analyses of the catch data suggest that these fishes have clumped distributions, and that they are stratified in the water column according to size. Thirty-three species are considered particularly important: four eel leptocephali, and 29 mesopelagic species (mostly gonostomatids and myctophids) that appear to spawn in the study area. These 33 species account for 92 percent of all the specimens taken and 70 percent of the total biomass. Because of the diversity of distributional patterns in midwater fishes, future monitoring of the study area should include discrete-depth sampling throughout the water column at all seasons of the year, and comparisons with a different area of the slope water.

INTRODUCTION

The midwater fishes of Deepwater Dumpsite 106 were sampled in May 1974, using 10 tows of a 10-foot (3.09-m) Isaacs-Kidd midwater trawl. The tows were made by the NOAA vessel RV Albatross IV. Richard L. Haedrich provided computer analyses of the data.

The purpose of this report is to provide a systematic analysis of the fishes taken in the 10 midwater tows. Although mesopelagic forms predominate, epipelagics and strays from the continental shelf are included. With the exception of eel larvae (leptocephali), some of which can be identified only to the generic or familial level, all undamaged individuals are identified as to species.

We have attempted to identify those species most likely to be affected by chemical dumping, using the following assumptions: 1) that the chemicals in question are progressively dispersed with increasing depth, and thus exert their greatest effects in the upper layers; and 2) that if these chemicals are toxic to fish life, they will be particularly injurious to larval stages. Since most deepsea fishes produce epipelagic larvae (Mead, Bertelsen, and Cohen, 1964), we have tried to identify those species that spawn in the Deepwater Dumpsite area.

¹ Final report of January 31, 1975, to the National Oceanic and Atmospheric Administration under Grant No. 04-4-158-49.

MATERIALS AND METHODS

Station data for the ten Isaacs-Kidd midwater trawls are presented in table 1. The sampling area is bounded by 39°04'N and 38°24'N and 71°29'W and 73°00'W. All sampling was done at night. On all tows the cable was payed out slowly until the desired depth was reached, and then slowly retrieved; thus all are oblique surface-depth-surface tows. Maximum depths were measured by a time-depth recorder attached to the trawl, and ranged from 550 to 790 m. Total trawl times varied from 1.22 to 3.27 hours.

Table 1.--Station data for Isaacs-Kidd midwater trawls

Trawl No.	Latitude		Longitude		Day May 1974	Time	Maximum depth (m)
	'N		'W			0-2400 hours	
1	38	46	72	47	11,12	2341-0245	750
2	38	37	73	00	13,14	2301-0014	675
3	38	37	73	00	14	0035-0200	790
4	39	04	72	34	16	0128-0346	620
5	38	56	72	18	17	0020-0156	720
6	38	42	72	00	18	0007-0235	615
7	38	54	72	07	18,19	2315-0205	640
8	38	40	72	33	19,20	2347-0303	630
9	38	24	71	59	20,21	2337-0140	550
10	38	41	71	29	21	2210-2357	550

Catches were preserved in 10% formalin aboard ship and transferred to 5% formalin in the laboratory. All specimens were identified to species where possible, and each individual was measured with dial calipers to the nearest millimeter (mm) standard length (SL). For each tow, the wet biomass of each species was measured to the nearest 0.1 milliliter (ml) by displacement in a graduated cylinder.

The life histories of most mesopelagic fishes are poorly known. The Isaacs-Kidd midwater trawl is ineffective in sampling small larvae, and for most of the species collected these diminutive stages, so important for determining spawning area, are absent. Since we have generally not examined gonads to determine the presence or absence of sexually mature individuals, our assessment of actual or probable spawners is based on a number of factors, including relative abundance, known geographic distributions, and size ranges, particularly in comparison with specimens from known spawning areas. Our terminology for life history stages follows that of Gibbs et al. (1971). Our taxonomic arrangement is based on Greenwood et al. (1966). Only for simplicity do we ignore Weitzman's (1974) meticulous revision of the stomiatoid fishes.

RESULTS AND DISCUSSION

The 10 trawls captured 4,029 specimens having a total volume of 2,523.4 ml. These specimens represent 114 species in 30 families and 10 orders. Table 2 summarizes the number of species, individuals, and volume by trawl.

The number of species taken per hour of trawling varied considerably, mainly due to the presence of many species represented by few specimens. Seventy three (64 percent) of the 114 species are represented by fewer than 10 individuals. Sizeable numbers of these uncommon species appeared for the first time ("new" species) as late as trawls 7 and 8, and the presence of 3 in the last trawl suggests that more intensive sampling would reveal others in the study area. In contrast, none of the numerically dominant species (see below) were taken as "new" later than the second trawl, indicating that no important species were missed.

If the species were randomly (or uniformly) distributed throughout the study area, then the number of individuals and volume in each trawl should be a function of trawl time. However, table 2 shows that in all 10 trawls the number of specimens and/or the total volume differs significantly from the values expected. We consider this additional evidence that most midwater fishes are strongly clumped (Pearcy, 1964; Ebeling et al., 1970; Bond, 1974). These nonrandom distributions may be partly explained by the stratification of species by size in the water column. Table 3 groups the data according to maximum trawl depth. Specimens decrease in number with increasing trawl depth, but increase in mean volume. Considering the trawling methodology, the increase of 0.13 ml/specimen with each 100 m increase in sampling depth is remarkable.

The need for more intensive sampling, preferably with a discrete-depth sampler, is clear. However, we feel that the present material represents a reasonable approximation of the mesopelagic fish fauna in the Deepwater Dumpsite area, and an accurate estimate of the number of dominant species present, at least in the month of May.

Complete data for all 114 species are given in Appendix A. We are eliminating (somewhat arbitrarily) from further consideration those 73 species represented by fewer than 10 specimens. We consider most of these to be incidental strays from other regions of the North Atlantic, including the continental shelf and the bathypelagic zone, and doubt that any reproduces in the Deepwater Dumpsite area. The numerically dominant species are further considered below.

ASSESSMENT OF NUMERICALLY DOMINANT SPECIES

Order Anguilliformes

Four eels taken only as leptocephali represent four families: Muraenidae (*Gymnothorax nigromarginatus*), Nettastomatidae (*Facciolella physonema*), Congridae (*Leptocephalus* sp. I) and Ophichthidae, (*Leptocephalus* sp.). These are conveniently discussed together.

Table 2.--Summary of catch data by trawl

	1	2	3	4	5	6	7	8	9	10	Total
Maximum depth (m)	750	675	790	620	720	615	640	630	550	550	--
Trawl time (hours)	3.06	1.21	1.41	2.30	1.60	2.46	2.83	3.26	2.05	1.78	21.96
Number of species	45	34	26	43	47	46	63	54	46	40	114
Species/hour	14.7	27.9	18.4	18.7	29.4	18.7	22.3	16.6	22.4	22.5	--
Number of "new" species	45	9	5	9	11	4	17	8	3	3	114
Number of specimens:											
expected ²	561	222	259	422	294	451	519	598	376	327	4029
observed ³	456**	170**	42**	333**	469**	497*	556	726**	449**	331	4029
Total volume:											
expected	351.5	139.0	162.0	264.2	184.0	282.6	325.3	374.5	235.7	204.6	2523.4
observed	405.6**	119.8	50.6**	259.0	24.94**	190.6**	425.6**	368.6	215.0	149.2**	2523.4

1

2

3

"New" species are those encountered for the first time.

Expected values are based on percentage trawl time.

Asterisks indicate observed values significantly different from expected as determined by chi-square analysis (* = .05; ** = .01; d.f. = 1).

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Table 3.--Distribution of specimens by maximum trawl depth

	Maximum depth (meters)		
	501-600	601-700	701-800
Trawl numbers	9,10	2,4,6,7,8	1,3,5
Total trawling time (hours)	3.83	12.06	6.07
No. of specimens	780	2282	967
Total volume (ml)	364.2	1363.6	705.6
Specimens/hour	203.7	189.2	159.3
Volume/hour	95.1	113.1	116.2
Mean volume/ specimen	0.47	0.60	0.73

Leptocephalous larvae occur in great numbers in the epipelagic zone, yet their taxonomy is poorly understood; most cannot yet be identified with any known adult. Studies on those species whose life histories are known indicate that leptocephali may travel great distances from their site of origin (see Castle, 1969). The skin of leptocephali appears incapable of acting as a barrier to the external environment (Hulet, 1972), and these larvae are almost isomotic with seawater (Hulet et al., 1972). Thus leptocephali may be particularly susceptible to pollutants, and although these four species may not be resident spawners, we consider them equally important.

Family Serrivomeridae

Serrivomer beanii. None of the 34 specimens of this species are leptocephali. However, the absence of larvae may be a function of the life history. S. beanii spawns in the northern Sargasso Sea, but the leptocephali are abundant only from January through March, and metamorphose in early spring (Tighe, 1975). The large number of specimens captured suggests that this species also spawns in the Deepwater Dump area.

Family Nemichthyidae

Nemichthys scolopaceus. The absence of leptocephali of this species is surprising, since N. scolopaceus is widely distributed in the western North Atlantic, and leptocephali are found throughout the year in the northern Sargasso Sea (Bengtson, 1973). The largest individual taken is within the size range of Bengtson's (1973) mature adults, and we tentatively assign this species to our list of spawners.

Order Salmoniformes

Family Gonostomatidae

Cyclothone spp. Cyclothone larvae are too small to be retained by the mesh of the IKMT (Bond, 1974), and none were captured. Five species were taken in moderate to large numbers: C. alba, C. braueri, C. microdon, C. pallida and C. pseudopallida. The size ranges of all five encompass the ranges given for juveniles as well as mature adults by Bond (1974), and we believe that all reproduce in the study area.

Gonostoma elongatum. This is the most abundant mesopelagic predator in the study area, represented by 37 specimens, 16-218 mm SL, with a total volume of 428 ml. Both larvae and adults are present, and this species undoubtedly spawns in the Deepwater Dump area.

Maurolicus muelleri. This is the third most abundant gonostomatid in the study area, exceeded only by Cyclothone braueri and C. microdon. We have sexed and staged each of the 361 specimens. Except for 4 subadult males and 5 subadult females, all are postlarvae or juveniles, indicating intensive spawning. The absence of mature adults suggests a one year life cycle. Okiyama (1971) reported that in the waters off Japan M. muelleri is most abundant near the edge of the continental shelf. This may also be true in the Atlantic, for in contrast to the present study material, only 2 and 4 specimens were reported by Beebe (1937) and Bond (1974), respectively, from intensive sampling off Bermuda.

Valenciennellus tripunctulatus. This species is widespread in the North Atlantic (Backus et al., 1970) and spawns throughout the year in the northern Sargasso Sea (Krueger, 1972). Although postlarvae are absent, the 10 specimens include juveniles as well as large adults, and we tentatively assign this species to our list of spawners.

Viniguerria nimbaria. Grey (1964) reported that this species is abundant in the North Atlantic only south of 35°N, and Backus et al. (1970) provisionally considered V. nimbaria a tropical species transported to the slope water by the Gulf Stream only as waifs. However, based on the sizes reported from the Indian Ocean (Silas and George, 1969), the present 30 specimens include postlarvae as well as adults, and we tentatively assign V. nimbaria to our list of spawners.

Family Sternoptychidae

Three hatchetfishes were taken in sizeable numbers: Argyropelecus aculeatus, A. hemigymnus and Sternoptyx diaphana. Baird (1971) considered the three to form a species assembly in the western North Atlantic, and noted for Argyropelecus that "Wherever a species is found in an area in numbers, it seems to represent a breeding population" (p. 106). The present study material includes postlarvae of all three species, and all undoubtedly spawn in the Deepwater Dump area.

Family Chauliodontidae

Chauliodus sloani is one of the most abundant large predators in the study area. One postlarva, 29 mm SL, was taken, and the large number of specimens (35) suggests a self-maintaining population.

Family Stomiatidae

Stomias boa ferox occurs throughout cooler waters of the western North Atlantic (Gibbs, 1969). Our 10 specimens are of postlarval to adult size (32-208 mm SL), and this species almost certainly spawns in the study area.

Family Paralepididae

Three species were common in the study area: Lestrolepis intermedia, Notolepis rissoi and Paralepis coregonoides. The study material includes specimens of postlarval size (Rofen, 1966) for each species, and we assume that all three spawn in the area.

Family Myctophidae

Benthosema glaciale. This is the most abundant lanternfish in the study area, with 480 specimens. These show a strikingly bimodal size distribution, 202 of the specimens measuring 10-16 mm SL, the rest 29-68 mm. The smaller specimens are comparable to young of the year described from the slope water off Nova Scotia by Halliday (1970), and B. glaciale unquestionably spawns in the Deepwater Dump area.

Benthosema suborbitale. The study material includes several specimens 10 to 11 mm SL, the size at which postlarvae of this species undergo metamorphosis (Moser and Ahlstrom, 1974). Although the species attains a size of about 30 mm, the largest of our 18 specimens is only 21 mm; however, this may be due to a one year life cycle. B. suborbitale is a broadly tropical species, occurring regularly in the slope water (Backus et al., 1970), and we tentatively include it in our list of spawners.

Bolinichthys indicus is represented by 21 specimens, 20-38 mm SL. This is the approximate size range of specimens taken in March-April in the northern Sargasso Sea, where the spawning peak is in early summer (Gibbs et al., 1971), and we tentatively add it to our list of spawners.

Ceratoscopelus maderensis. Although 40 specimens were taken, all are large (48-73 mm SL). Backus et al. (1970) characterized this as a northern species. Their figure 13 indicates that C. maderensis is far more abundant to the east and north of the study area, and larvae have been identified from the George's Bank area (Moser and Ahlstrom, 1970). We suspect that this species does not reproduce in the study area, and that the present specimens are expatriates from colder waters.

Ceratoscopelus warmingi. Backus et al. (1970) characterized this as a broadly tropical species that occurs regularly in the slope water. Our size range (16-60 mm SL) is similar to that in the northern Sargasso Sea, where the species maintains a resident population (Gibbs et al., 1971), and we include it in our list of spawners.

Diaphus dumerili is the second most abundant myctophid, with 165 specimens, 13-46 mm SL. Nafpaktitus (1968) found this species common off the continental slope from the Bahamas to Cape Cod, but recognized only two spawning populations, one in the eastern Caribbean, the other in the Gulf of Guinea. He found no ripe females smaller than 52 mm SL in the Caribbean, while those in the Gulf of Guinea were mature at a much smaller size (40-42mm). Examination of the gonads of our four largest specimens (42-46 mm SL) reveals that all are subadults. Three are females, with eggs ca. 0.1 mm in diameter. The single male has small but clearly recognizable testes. These specimens

may represent maturing individuals that spawn in summer. At any rate, we cannot dismiss 165 specimens as waifs, and suspect that D. dumerili spawns in the study area as relatively small adults, as it does in the Gulf of Guinea.

Diaphus rafinesquei spawns in the eastern Atlantic, and the small size (13-35 mm SL) of our few specimens (15) supports Nafpaktitis' (1968) contention that this species is transported into the western Atlantic as waifs.

Diogenichthys atlanticus is widespread in the North Atlantic (Backus et al., 1970). This is a diminutive species, and the size range of our specimens (12-21 mm SL) is comparable to that in the northern Sargasso Sea, where D. atlanticus is known to spawn (Gibbs et al., 1971). We consider the present 26 specimens to represent a spawning population in the Deepwater Dump area.

Hygophum benoiti is represented by only 10 small specimens, 12 to 17 mm SL. The peak spawning period in the northern Sargasso Sea is in March (Gibbs et al., 1971), suggesting that the present specimens are waifs from waters to the southwest.

Hygophum hygomi is the third most abundant myctophid, with 95 specimens, 14 to 49 mm SL. The size range is very similar to that of specimens taken in March and April in the northern Sargasso Sea, where the species spawns in late fall and winter (Gibbs et al., 1971), suggesting that it spawns in the study area as well.

Lampanyctus alatus is a tropical species (Backus et al., 1970), and we consider the present 24 specimens (15-48 mm SL) waifs from waters to the southwest.

Lampanyctus pusillus is represented by 12 specimens, 16 to 40 mm SL. This is a northern species (Backus et al., 1970), and the size range of our specimens is very similar to that of individuals taken in April in the northern Sargasso Sea, where L. pusillus spawns year-round (Gibbs et al., 1971). We tentatively include it in our list of spawners.

Lepidophanes guentheri is a tropical species (Backus et al., 1970). Our 34 specimens fall into two size ranges, 15 to 29 and 39 to 62 mm SL, both present in approximately equal numbers. We consider these to represent two year classes of waifs, the smaller specimens consisting of recent arrivals, the larger ones representing individuals which survive in the slope water but are incapable of reproduction.

Lobianchia dofleini is represented by 14 specimens, 16 to 35 mm SL. O'Day and Nafpaktitis (1967) showed that individuals of L. dofleini are expatriated from the eastern Atlantic and fail to develop ripe gonads in waters west of 45° W.

Myctophum affine is represented by 15 small specimens, 15 to 32 mm SL; the species attains a maximum size of over 60 mm SL (Gibbs, 1957). This is a tropical species (Backus et al., 1970), and probably occurs in the slope water only as waifs.

Notoscopelus valdiviae is a diminutive species, represented here by 30 specimens, 10 to 21 mm SL. The species is widespread in the North Atlantic (Backus et al., 1970), and our size range approximates that of the large spawning population in the northern Sargasso Sea (Gibbs et al., 1971). We include it in our list of spawners.

Notoscopelus resplendens is another species characterized by Backus et al. (1970) as broadly tropical in distribution, occurring regularly in the slope water. Our 33 specimens range from 23 to 69 mm SL. Twenty-nine of these are in the 23 to 38 mm range and probably represent the products of a single spawning, suggesting that N. resplendens reproduces in the study area in late fall and winter, as it does in the northern Sargasso Sea (Gibbs et al., 1971).

Order Beryciformes

Family Melamphaidae

Scopelogadus beanii is represented by 13 specimens, 66 to 114 mm SL. Ebeling and Weed (1963) showed that postlarvae and young are found in warmer waters, and the absence of small specimens indicates that S. beanii does not reproduce in the Deepwater Dump area.

Table 4 summarizes the data for those species that we consider most important at the Deepwater Dumpsite. The first four are leptocephalus eel larvae, the remaining 29 are mesopelagic species that we consider to be reproducing in the study area. These 33 species encompass 91.6 percent of all the specimens taken in the 10 trawls, and 70.5 percent of the total volume. Some of our designations of spawners are based on limited evidence and may prove to be incorrect. However, we believe that our estimate is conservative. Many mesopelagic species show pronounced seasonal spawning peaks and corresponding changes in the abundance of various life history stages (Gibbs et al., 1971; Bond, 1974). Thus, some of the species omitted from our list of spawners on the basis of small numbers, or because of the absence of either very small or adult-sized specimens, may yet be shown to reproduce in the study area. The obvious solution is to examine large series of specimens collected throughout the year.

Although none of these species is considered to be of direct importance to man, all are involved in pelagic food chains, and most can be expected to enter the diets of commercially important fishes such as tunas (e.g. Harrison, 1967). Therefore, any decline in their populations could have adverse long-term effects on the economy of the ocean.

Ideally, the possible effects of the pollutants that are introduced at the Deepwater Dumpsite should be tested directly in the laboratory. This would be a formidable task, complicated by the fact that mesopelagic fishes are very difficult to maintain in captivity, although some progress has been made in this effort (Robison, 1973). An alternative is to sample the study area on a quantitative basis, and to compare the results with a similar sampling of a slope water area beyond the influence of the pollutants. Since depth preferences, spawning times, and the relative abundance of life history stages vary widely among species, this sampling should include: 1) repetitive hori-

zontal tows at vertical intervals of 50 meters throughout the water column at all seasons of the year, using a midwater trawl equipped with an opening-closing device; and 2) plankton tows throughout the upper 200 meters to determine the presence or absence of larvae.

Table 4.--Leptocephali and known or suspected spawners in Deepwater
Dumpsite 106

Family	Species	Specimens	Volume (ml)
Muraenidae	<u>Gymnothorax nigromarginatus</u>	25	5.0
Nettastomatidae	<u>Facciolella physonema</u>	19	5.9
Congridae	<u>Leptocephalus sp.1</u>	24	13.0
Ophichthidae	<u>Leptocephalus sp.</u>	17	2.7
Serrivomeridae	<u>Serrivomer beanii</u>	34	66.8
Nemichthyidae	<u>Nemichthys scolopaceus</u>	15	67.4
Gonostomatidae	<u>Cyclothone alba</u>	36	1.5
	<u>C. braueri</u>	383	20.4
	<u>C. microdon</u>	1300	111.6
	<u>C. pallida</u>	111	11.8
	<u>C. pseudopallida</u>	126	11.9
	<u>Gonostoma elongatum</u>	37	427.5
	<u>Maurollicus muelleri</u>	361	120.5
	<u>Valenciennellus tripunctulatus</u>	10	1.5
	<u>Vinciguerrina nimbaria</u>	30	4.5
Sternoptychidae	<u>Argyropelecus aculeatus</u>	27	50.6
	<u>A. hemigymnus</u>	19	8.4
	<u>Sternoptyx diaphana</u>	69	27.0
Chauliodontidae	<u>Chauliodus sloani</u>	35	284.6
Stomiidae	<u>Stomias boa ferox</u>	10	27.2
Paralepididae	<u>Lestrolepis intermedia</u>	22	2.0
	<u>Notolepis rissoi</u>	48	3.0
	<u>Paralepis coregonoides</u>	18	2.4
Myctophidae	<u>Benthosema glaciale</u>	480	335.9
	<u>B. suborbitale</u>	18	1.5
	<u>Bolinichthys indicus</u>	21	10.6
	<u>Ceratoscopelus warmingi</u>	36	14.4
	<u>Diaphus dumerili</u>	165	33.3
	<u>Diogenichthys atlanticus</u>	26	2.6
	<u>Hygophum hygomi</u>	95	76.1
	<u>Lampanyctus pusillus</u>	12	3.5
	<u>Notolychnus valdiviae</u>	30	2.0
	<u>Notoscopelus resplendens</u>	33	21.2
	Total	3692	1778.3

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APPENDIX A.--Number of specimens and size range and volume of each fish species taken in midwater trawls.

species taken in midwater trawls.				
Station	Quantity	Size (mm SL)		Volume
		min.	max.	(ml)
<u>Anguilliformes</u>				
<u>Anguilloidei</u>				
<u>Muraenidae</u>				
<u>Gymnothorax</u>		<u>nigromarginatus</u>		
MWT	2	2	65- 80	.6
MWT	3	1	55- 55	.1
MWT	4	3	42- 53	1.0
MWT	5	4	45- 81	1.0
MWT	6	5	46- 77	.5
MWT	7	1	57- 57	.1
MWT	8	3	62- 64	.2
MWT	9	6	41- 100	1.5
Total		25	41- 100	5.0
<u>Nettastomatidae</u>				
<u>Nettastoma</u>		<u>melanurum</u>		
MWT	8	1	62- 62	.2
Total		1	62- 62	.2
<u>Facciolella</u>		<u>physonema</u>		
MWT	1	1	112- 112	.4
MWT	4	6	80- 127	3.0
MWT	5	3	78- 132	1.0
MWT	6	2	101- 172	.5
MWT	8	3	80- 98	.5
MWT	9	2	84- 112	.3
MWT	10	2	108- 109	.2
Total		19	78- 172	5.9
<u>Nessorhamphidae</u>				
<u>Nessorhamphus</u>		<u>ingolfianus</u>		
MWT	5	2	149- 201	4.0
Total		2	149- 201	4.0
<u>Congridae</u>				
<u>Leptocephalus</u>		<u>sp 1</u>		
MWT	1	2	74- 83	.7
MWT	2	1	101- 101	1.0
MWT	4	5	69- 93	3.8
MWT	6	3	32- 103	1.8
MWT	7	3	77- 90	1.3
MWT	9	5	81- 109	4.0
MWT	10	5	66- 110	.4
Total		24	32- 110	13.0

	Station	Quantity	Size (mm SL)		Volume (ml)
			min.	max.	
<u>Leptocephalus</u>		<u>sp</u> 2			
MWT	3	2	94-	107	3.0
MWT	5	3	74-	108	2.0
Total		5	74-	108	5.0
<u>Leptocephalus</u>		<u>sp</u> 3			
MWT	5	1	111-	111	2.0
Total		1	111-	111	2.0
<u>Ariosoma</u>		<u>balearicum</u>			
MWT	3	1	158-	158	4.0
MWT	8	1	154-	154	4.0
Total		2	154-	158	8.0
<u>Ophichthidae</u>					
<u>Leptocephalus</u>		<u>sp</u>			
MWT	1	1	57-	57	.2
MWT	2	1	65-	65	.3
MWT	3	1	50-	50	.1
MWT	4	2	42-	67	.9
MWT	5	1	77-	77	.3
MWT	6	3	55-	76	.2
MWT	8	4	66-	85	.5
MWT	9	1	56	56	.1
MWT	10	3	42-	66	.1
Total		17	42-	85	2.7
<u>Dysommidae</u>					
<u>Dysomma</u>		<u>anguillare</u>			
MWT	8	1	34-	34	.1
Total		1	34-	34	.1
<u>Derichthyidae</u>					
<u>Derichthys</u>		<u>serpentinus</u>			
MWT	3	1	142-	142	2.3
MWT	4	2	189-	218	11.0
MWT	7	2	166-	243	12.2
MWT	9	1	260-	260	13.0
MWT	10	3	148-	175	10.0
Total		9	142-	260	48.5
<u>Serrivomeridae</u>					
<u>Serrivomer</u>		<u>beanii</u>			
MWT	1	5	137-	407	17.0
MWT	4	5	128-	389	14.0
MWT	5	3	240-	300	3.0
MWT	6	4	200-	435	20.0
MWT	7	4	101-	236	1.7
MWT	8	5	120-	284	4.0
MWT	9	3	146-	357	4.1
MWT	10	5	110-	255	3.0
Total		34	101-	435	66.8

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	Station	Quantity	Size (mm SL)		Volume (ml)
			min.	max.	
<u>Nemichthyidae</u>					
<u>Nemichthys</u>		<u>scolopaceus</u>			
MWT	1	3	120-	575	4.0
MWT	2	2	360-	510	14.0
MWT	3	2	344-	482	13.0
MWT	4	1	962-	962	23.0
MWT	5	4	260-	494	4.5
MWT	6	2	251-	569	5.2
MWT	8	1	554-	554	3.7
Total		15	120-	962	67.4
<u>Notacanthiformes</u>					
<u>Notacanthidae</u>					
<u>Tiluroopsis</u>		sp.			
MWT	7	1	435-	435	1.5
Total		1	435-	435	1.5
<u>Salmoniformes</u>					
<u>Argentinoidei</u>					
<u>Bathylagidae</u>					
<u>Bathylagus</u>		<u>longirostris</u>			
MWT	1	1	44-	44	.6
MWT	7	1	122-	122	12.0
MWT	8	1	95-	95	5.0
Total		3	44-	122	17.6
<u>Bathylagus</u>		<u>microcephalus</u>			
MWT	8	1	47-	47	1.0
MWT	10	1	78-	78	3.4
Total		2	47-	78	4.4
<u>Stomiatoidei</u>					
<u>Gonostomatidae</u>					
<u>Bonapartia</u>		<u>pedaliota</u>			
MWT	7	9	40-	63	11.4
Total		9	40-	63	11.4
<u>Cyclothone</u>		<u>acclinidens</u>			
MWT	1	1	21-	21	.1
MWT	5	2	27-	32	.3
Total		3	21-	32	.4
<u>Cyclothone</u>		<u>alba</u>			
MWT	1	4	18-	25	.2
MWT	2	2	16-	16	.1
MWT	4	7	15-	28	.2
MWT	5	6	14-	28	.3
MWT	6	3	16-	21	.1
MWT	7	5	14-	24	.2
MWT	8	3	20-	28	.2
MWT	9	4	15-	22	.1
MWT	10	2	20-	25	.1
Total		36	14-	28	1.5

	Station	Quantity	Size (mm SL)		Volume
			min.	max.	(ml)
<u>Cyclothone</u>					
		<u>braueri</u>			
MWT	1	63	14-	29	3.5
MWT	2	14	15-	27	1.0
MWT	3	1	16-	16	.1
MWT	4	56	14-	26	2.0
MWT	5	45	15-	29	2.1
MWT	6	16	15-	22	.5
MWT	7	118	13-	29	8.0
MWT	8	41	13-	29	1.5
MWT	9	18	16-	29	1.0
MWT	10	11	18-	30	.7
Total		383	13-	30	20.4
<u>Cyclothone</u>					
		<u>microdon</u>			
MWT	1	193	12-	52	20.0
MWT	2	74	16-	45	12.5
MWT	3	7	17-	42	.8
MWT	4	107	13-	47	7.0
MWT	5	189	14-	47	19.0
MWT	6	159	10-	54	12.0
MWT	7	118	14-	40	8.4
MWT	8	184	12-	53	19.2
MWT	9	165	12-	53	7.7
MWT	10	104	14-	36	5.0
Total		1300	10-	54	111.6
<u>Cyclothone</u>					
		<u>pallida</u>			
MWT	1	15	16-	53	2.0
MWT	2	9	20-	53	1.4
MWT	3	3	22-	42	.4
MWT	4	7	18-	30	.3
MWT	5	27	18-	61	4.3
MWT	6	3	24-	49	.4
MWT	7	10	20-	26	.8
MWT	8	10	21-	47	1.1
MWT	9	15	14-	22	.5
MWT	10	12	17-	28	.6
Total		111	14-	61	11.8
<u>Cyclothone</u>					
		<u>pseudopallida</u>			
MWT	1	19	13-	38	1.1
MWT	2	8	18-	46	1.0
MWT	4	3	28-	34	.1
MWT	5	11	21-	38	1.1
MWT	6	20	13-	47	2.0
MWT	7	11	14-	41	1.4
MWT	8	17	17-	42	2.0
MWT	9	21	16-	36	1.2
MWT	10	16	19-	45	2.0
Total		126	13-	47	11.9

	Station	Quantity	Size (mm SL)		Volume (ml)
			min.	max.	
<u>Gonostoma</u>		<u>atlanticum</u>			
MWT	1	1	55-	55	1.1
Total		1	55-	55	1.1
<u>Gonostoma</u>		<u>elongatum</u>			
MWT	1	6	102-	200	135.0
MWT	2	1	155-	155	15.0
MWT	3	1	166-	166	16.0
MWT	4	9	28-	200	80.0
MWT	5	5	65-	218	53.0
MWT	7	2	52-	102	5.0
MWT	8	5	16-	160	26.0
MWT	9	6	35-	200	37.5
MWT	10	2	193-	202	60.0
Total		37	16-	218	427.5
<u>Ichthyococcus</u>		<u>ovatus</u>			
MWT	7	1	37-	37	1.0
Total		1	37-	37	1.0
<u>Maurolicus</u>		<u>muelleri</u>			
MWT	1	9	9-	26	.5
MWT	2	3	8-	11	.1
MWT	4	14	9-	30	1.0
MWT	5	33	8-	38	3.3
MWT	6	26	10-	33	3.6
MWT	7	9	10-	38	3.0
MWT	8	223	15-	39	98.0
MWT	9	19	13-	34	4.0
MWT	10	25	11-	36	7.0
Total		361	8-	39	120.5
<u>Pollichthys</u>		<u>mauli</u>			
MWT	6	1	27-	27	.1
MWT	7	3	34-	42	1.0
MWT	10	1	25-	25	.1
Total		5	25-	42	1.2
<u>Valenciennellus</u>		<u>tripunctulatus</u>			
MWT	1	2	19-	24	.2
MWT	3	1	24-	24	.1
MWT	6	2	24-	25	.3
MWT	7	1	27-	27	.6
MWT	8	3	16-	24	.2
MWT	10	1	19-	19	.1
Total		10	16-	27	1.5
<u>Vinciguerria</u>		<u>attenuata</u>			
MWT	9	4	19-	45	2.0
Total		4	19-	45	2.0

		Station	Quantity	Size (mm SL)		Volume (ml)
				min.	max.	
<u>Vinciguerria</u>			<u>nimbaria</u>			
MWT	1		2	16-	17	.1
MWT	2		2	25-	28	1.0
MWT	3		2	24-	29	.3
MWT	4		7	16-	35	1.4
MWT	5		5	13-	26	.5
MWT	6		5	15-	26	.4
MWT	8		3	21-	24	.3
MWT	9		1	30-	30	.2
MWT	10		3	20-	29	.3
Total			30	13-	35	4.5
<u>Vinciguerria</u>			<u>poweriae</u>			
MWT	1		1	18-	18	.1
MWT	2		1	16-	16	.1
MWT	3		1	19-	19	.1
MWT	8		4	17-	33	.8
MWT	10		2	20-	24	.2
Total			9	16-	33	1.3
<u>Sternoptychidae</u>						
<u>Argyropelecus</u>			<u>aculeatus</u>			
MWT	2		1	18-	18	.4
MWT	3		1	21-	21	.5
MWT	5		2	23-	56	5.0
MWT	6		1	13-	13	.1
MWT	7		3	20-	23	2.0
MWT	8		2	37-	44	6.0
MWT	9		15	11-	49	32.0
MWT	10		2	31-	46	4.6
Total			27	11-	56	50.6
<u>Argyropelecus</u>			<u>affinis</u>			
MWT	4		2	9-	21	1.0
Total			2	9-	21	1.0
<u>Argyropelecus</u>			<u>hemigymnus</u>			
MWT	3		1	25-	25	.4
MWT	4		2	14-	31	1.3
MWT	5		2	13-	33	1.5
MWT	6		2	11-	12	.1
MWT	7		6	14-	32	3.0
MWT	8		2	20-	24	1.0
MWT	9		2	12-	32	1.0
MWT	10		2	8-	15	.1
Total			19	8-	33	8.4

	Station	Quantity	Size (mm SL)		Volume (ml)
			min.	max.	
<u>Sternoptyx</u>		<u>diaphana</u>			
MWT	1	6	9-	25	3.0
MWT	2	2	11-	18	.7
MWT	4	8	10-	24	4.0
MWT	5	4	14-	20	1.2
MWT	6	29	8-	29	9.5
MWT	7	5	13-	18	1.4
MWT	8	8	12-	25	3.2
MWT	9	7	7-	28	4.0
Total		69	7-	29	27.0
<u>Melanostomiatidae</u>					
<u>Echiostoma</u>		<u>barbatum</u>			
MWT	5	1	58-	58	.9
Total		1	58-	58	.9
<u>Eustomias</u>		<u>sp</u>			
MWT	5	2	67-	79	1.0
MWT	8	2	42-	66	.3
MWT	9	1	106-	106	2.2
Total		5	42-	106	3.5
<u>Pachystomias</u>		<u>microdon</u>			
MWT	7	1	42-	42	.2
Total		1	42-	42	.2
<u>Photonectes</u>		<u>margarita</u>			
MWT	7	1	47-	47	.2
Total		1	47-	47	.2
<u>Malacosteidae</u>					
<u>Aristostomias</u>		<u>sp</u>			
MWT	7	1	191-	191	41.0
Total		1	191-	191	41.0
<u>Malacosteus</u>		<u>niger</u>			
MWT	5	1	99-	99	3.5
MWT	8	1	128-	128	7.0
Total		2	99-	128	10.5
<u>Photostomias</u>		<u>guernei</u>			
MWT	2	1	112-	112	6.8
Total		1	112-	112	6.8

Station		Quantity	Size (mm SL)		Volume
			min.	max.	(ml)
<u>Chauliodontidae</u>					
<u>Chauliodus</u>		<u>sloani</u>			
MWT	1	7	61-	201	80.0
MWT	2	1	168-	168	15.0
MWT	3	2	57-	89	2.4
MWT	4	4	126-	204	50.0
MWT	6	3	61-	202	24.0
MWT	7	2	50-	255	61.0
MWT	8	9	29-	151	16.0
MWT	9	2	28-	29	.2
MWT	10	5	58-	194	36.0
Total		35	28-	255	284.6
<u>Stomiidae</u>					
<u>Stomias</u>		<u>affinis</u>			
MWT	6	1	54-	54	.3
Total			54-	54	.3
<u>Stomias</u>		<u>boa ferox</u>			
MWT	1	2	141-	152	8.0
MWT	2	1	208-	208	10.5
MWT	3	1	76-	76	.7
MWT	4	2	32-	117	4.0
MWT	5	1	74-	74	1.9
MWT	6	1	90-	90	.6
MWT	7	1	33-	33	.1
MWT	8	1	114-	114	1.4
Total		10	32-	208	27.2
<u>Myctophoidei</u>					
<u>Paralepididae</u>					
<u>Lestidiops</u>		<u>affinis</u>			
MWT	10	1	60-	60	.3
Total		1	60-	60	.3
<u>Lestidiops</u>		<u>jayakari</u>			
MWT	8	1	29-	29	.1
MWT	10	1	46-	46	.2
Total		2	29-	46	.3
<u>Lestidium</u>		<u>atlanticum</u>			
MWT	7	1	53-	53	.2
MWT	8	1	84-	84	.9
Total		2	53-	84	1.1

	Station	Quantity	Size (mm SL)		Volume (ml)
			min.	max.	
<u>Lestrolepis</u>		<u>intermedia</u>			
MWT	1	2	44-	45	.2
MWT	3	1	27-	27	.1
MWT	4	2	46-	46	.2
MWT	5	7	24-	52	.5
MWT	6	1	67-	67	.3
MWT	7	3	50-	52	.3
MWT	8	2	38-	39	.1
MWT	9	4	34-	51	.3
Total		22	24-	67	2.0
<u>Notolepis</u>		<u>rissoi</u>			
MWT	1	2	52-	60	.5
MWT	4	3	19-	45	.2
MWT	5	2	21-	26	.1
MWT	6	2	32-	39	.1
MWT	7	30	21-	41	1.5
MWT	8	6	27-	32	.3
MWT	10	3	24-	56	.3
Total		48	19-	60	3.0
<u>Paralepis</u>		<u>coregonoides</u>			
MWT	1	3	30-	43	.5
MWT	2	1	28-	28	.1
MWT	4	1	27-	27	.1
MWT	5	1	28-	28	.2
MWT	6	1	47-	47	.3
MWT	7	6	27-	37	.6
MWT	8	4	29-	43	.5
MWT	10	1	36-	36	.1
Total		18	27-	47	2.4
<u>Paralepis</u>		<u>elongata</u>			
MWT	7	1	86-	86	1.6
Total		1	86-	86	1.6
<u>Stemonosudis</u>		<u>intermedia</u>			
MWT	10	1	57-	57	.2
Total		1	57-	57	.2
<u>Scopelarchidae</u>		<u>analis</u>			
<u>Scopelarchus</u>					
MWT	8	1	27-	27	.1
Total		1	27-	27	.1

Station		Quantity	Size (mm SL)		Volume (ml)
			min.	max.	
<u>Myctophidae</u>					
<u>Benthoosema</u>		<u>glaciale</u>			
MWT	1	56	12-	63	63.0
MWT	2	10	10-	53	7.5
MWT	3	1	12-	12	.1
MWT	4	16	12-	60	17.4
MWT	5	52	12-	63	61.0
MWT	6	68	11-	64	58.0
MWT	7	85	11-	64	39.0
MWT	8	57	11-	68	65.0
MWT	9	51	11-	60	19.0
MWT	10	84	11-	44	5.5
Total		480	10-	68	335.5
<u>Benthoosema</u>		<u>suborbitale</u>			
MWT	1	3	11-	12	.1
MWT	2	2	10-	20	.5
MWT	5	1	17-	17	.1
MWT	6	2	15-	18	.1
MWT	7	1	21-	21	.1
MWT	8	3	11-	18	.2
MWT	9	4	11-	19	.3
MWT	10	2	16-	17	.1
Total		18	10-	21	1.5
<u>Bolinichthys</u>		<u>indicus</u>			
MWT	4	4	20-	32	1.3
MWT	5	1	31-	31	.4
MWT	7	15	24-	38	8.4
MWT	9	1	32-	32	.5
Total		21	20-	38	10.6
<u>Bolinichthys</u>		<u>supralateralis</u>			
MWT	3	1	37-	37	.7
MWT	7	1	34-	34	.6
Total		2	34-	37	1.3
<u>Centrobranchus</u>		<u>nigroocellatus</u>			
MWT	7	1	33-	33	.4
Total		1	33-	33	.4

		Station	Quantity	Size (mm SL)		Volume
				min.	max.	(ml)
<u>Ceratoscopelus</u>			<u>maderensis</u>			
MWT	1		4	55-	70	11.0
MWT	2		1	67-	67	2.5
MWT	3		2	54-	55	3.8
MWT	5		11	48-	58	19.5
MWT	6		5	54-	73	14.7
MWT	8		11	53-	65	26.8
MWT	9		5	51-	67	11.0
MWT	10		1	64-	64	3.0
Total			40	48-	73	92.3
<u>Ceratoscopelus</u>			<u>warmingi</u>			
MWT	2		2	26-	39	1.0
MWT	4		7	17-	47	4.3
MWT	6		9	16-	20	.8
MWT	7		2	17-	33	.5
MWT	8		4	18-	46	2.5
MWT	9		7	18-	60	4.5
MWT	10		5	18-	30	.8
Total			36	16-	60	14.4
<u>Diaphus</u>			<u>dumerili</u>			
MWT	1		8	13-	27	1.2
MWT	2		12	15-	36	2.0
MWT	3		2	16-	28	.4
MWT	4		12	13-	32	2.4
MWT	5		8	14-	33	1.3
MWT	6		48	14-	42	7.0
MWT	7		2	15-	21	.2
MWT	8		38	16-	37	9.4
MWT	9		25	15-	46	7.0
MWT	10		10	16-	33	2.4
Total			165	13-	46	33.3
<u>Diaphus</u>			<u>metopoclampus</u>			
MWT	4		1	23-	23	.3
MWT	5		1	24-	24	.2
MWT	7		2	53-	65	8.0
MWT	9		1	17-	17	.1
Total			5	17-	65	8.6
<u>Diaphus</u>			<u>mollis</u>			
MWT	5		1	44-	44	1.3
MWT	9		1	18-	18	.1
Total			2	18-	44	1.4

	Station	Quantity	Size (mm SL)		Volume (ml)
			min.	max.	
<u>Diaphus</u>		<u>rafinesquei</u>			
MWT	2	1	33-	33	.8
MWT	4	5	15-	24	1.6
MWT	5	3	13-	28	.4
MWT	6	1	14-	14	.1
MWT	7	4	17-	35	1.2
MWT	10	1	15-	15	.1
Total		15	13-	35	4.2
<u>Diaphus</u>		<u>taaningi</u>			
MWT	1	1	23-	23	.2
Total		1	23-	23	.2
<u>Diogenichthys</u>		<u>atlanticus</u>			
MWT	2	2	17-	19	.2
MWT	5	4	14-	20	.3
MWT	6	1	12-	12	.1
MWT	7	17	12-	21	1.8
MWT	9	1	15-	15	.1
MWT	10	1	20-	20	.1
Total		26	12-	21	2.6
<u>Gonichthys</u>		<u>coccoi</u>			
MWT	1	1	28-	28	.2
MWT	2	1	20-	20	.1
MWT	7	1	39-	39	.5
Total		3	20-	39	.8
<u>Hygophum</u>		<u>benoiti</u>			
MWT	5	1	14-	14	.1
MWT	6	7	12-	15	.2
MWT	7	1	13-	13	.1
MWT	8	1	17-	17	.1
Total		10	12-	17	.5
<u>Hygophum</u>		<u>hygomi</u>			
MWT	1	14	28-	49	9.7
MWT	2	3	26-	44	2.0
MWT	3	2	19-	31	.5
MWT	4	4	44-	48	7.0
MWT	5	7	30-	47	6.0
MWT	6	19	21-	43	12.5
MWT	7	13	22-	46	10.5
MWT	8	23	20-	45	17.5
MWT	9	8	32-	49	9.7
MWT	10	2	14-	33	.7
Total		95	14-	49	76.1

	Station	Quantity	Size (mm SL)		Volume (ml)
			min.	max.	
<u>Hygophum</u>		<u>reinhardti</u>			
MWT	10	1	23-	23	.1
Total		1	23-	23	.1
<u>Hygophum</u>		<u>taaningi</u>			
MWT	1	2	13-	16	.1
MWT	4	1	15-	15	.1
MWT	6	5	12-	25	.4
MWT	7	1	19-	19	.1
Total		9	12-	25	.7
<u>Lampadena</u>		<u>anomala</u>			
MWT	9	1	48-	48	.7
Total		1	48-	48	.7
<u>Lampadena</u>		<u>luminosa</u>			
MWT	7	1	26-	26	.2
Total		1	26-	26	.2
<u>Lampadena</u>		<u>urophaos</u>			
MWT	4	1	26-	26	.2
Total		1	26-	26	.2
<u>Lampanyctus</u>		<u>alatus</u>			
MWT	1	1	34-	34	.5
MWT	4	3	20-	44	1.1
MWT	6	5	16-	40	1.1
MWT	7	3	16-	28	.3
MWT	8	4	15-	48	1.6
MWT	9	7	17-	27	.7
MWT	10	1	18-	18	.1
Total		24	15-	48	5.4
<u>Lampanyctus</u>		<u>ater</u>			
MWT	1	1	82-	82	3.0
MWT	2	1	81-	81	4.0
MWT	4	1	55-	55	.8
MWT	5	2	33-	102	8.7
MWT	6	1	70-	70	1.8
MWT	7	1	80-	80	3.2
Total		7	33-	102	21.5
<u>Lampanyctus</u>		<u>crocodilus</u>			
MWT	8	2	26-	49	1.0
Total		2	26-	49	1.0

		Station	Quantity	Size (mm SL)		Volume
				min.	max.	(ml)
<u>Lampanyctus</u>			<u>cuprarius</u>			
MWT	1		1	31-	31	.3
MWT	6		1	48-	48	.8
MWT	8		1	73-	73	2.9
Total			3	31-	73	4.0
<u>Lampanyctus</u>			<u>festivus</u>			
MWT	6		1	21-	21	.1
Total			1	21-	21	.1
<u>Lampanyctus</u>			<u>lineatus</u>			
MWT	7		2	62-	71	3.2
Total			2	62-	71	3.2
<u>Lampanyctus</u>			<u>macdonaldi</u>			
MWT	7		1	129-	129	17.0
Total			1	129-	129	17.0
<u>Lampanyctus</u>			<u>photonotus</u>			
MWT	7		2	59-	59	4.7
Total			2	59-	59	4.7
<u>Lampanyctus</u>			<u>pusillus</u>			
MWT	4		1	40-	40	.7
MWT	5		1	21-	21	.1
MWT	6		1	16-	16	.1
MWT	7		6	21-	39	1.6
MWT	9		3	23-	37	1.0
Total			12	16-	40	3.5
<u>Lepidophanes</u>			<u>gaussi</u>			
MWT	4		2	16-	16	.1
MWT	7		2	24-	24	.3
Total			4	16-	24	.4
<u>Lepidophanes</u>			<u>guentheri</u>			
MWT	1		1	22-	22	.1
MWT	2		1	50-	50	1.2
MWT	3		2	21-	25	.3
MWT	4		9	16-	58	5.3
MWT	6		4	15-	52	1.7
MWT	7		7	16-	62	4.7
MWT	8		4	29-	51	3.4
MWT	9		5	15-	56	2.8
MWT	10		1	24-	24	.1
Total			34	15-	62	19.6

		Station	Quantity	Size (mm SL)		Volume
				min.	max.	(ml)
<u>Lobianchia</u>			<u>dofleini</u>			
MWT	2		2	19-	19	.2
MWT	4		1	24-	24	.4
MWT	5		1	19-	19	.1
MWT	6		3	16-	28	.7
MWT	7		2	25-	35	1.0
MWT	8		3	20-	21	.5
MWT	9		1	24-	24	.3
MWT	10		1	34-	34	.3
Total			14	16-	35	3.5
<u>Lobianchia</u>			<u>gemellari</u>			
MWT	7		4	28-	78	17.0
Total			4	28-	78	17.0
<u>Loweina</u>			<u>rara</u>			
MWT	5		1	33-	33	.4
Total			1	33-	33	.4
<u>Myctophum</u>			<u>affine</u>			
MWT	1		3	26-	28	.7
MWT	4		1	31-	31	.8
MWT	6		6	15-	32	.6
MWT	8		1	25-	25	.2
MWT	9		1	17-	17	.1
MWT	10		3	18-	26	.5
Total			15	15-	32	2.9
<u>Myctophum</u>			<u>asperum</u>			
MWT	8		1	15-	15	.1
Total			1	15-	15	.1
<u>Myctophum</u>			<u>nitidulum</u>			
MWT	1		1	24-	24	.2
Total			1	24-	24	.2
<u>Myctophum</u>			<u>obtusirostris</u>			
MWT	1		1	28-	28	.3
MWT	3		1	16-	16	.1
Total			2	16-	28	.4
<u>Myctophum</u>			<u>punctatum</u>			
MWT	8		1	22-	22	.1
Total			1	22-	22	.1

	Station	Quantity	Size (mm SL)		Volume (ml)
			min.	max.	
<u>Notolychnus</u>					
		<u>valdiviae</u>			
MWT	4	1	20-	20	.1
MWT	6	6	13-	20	.2
MWT	7	6	10-	21	.5
MWT	8	4	16-	20	.3
MWT	9	10	14-	21	.7
MWT	10	3	19-	21	.2
Total		30	10-	21	2.0
<u>Notoscopelus</u>					
		<u>caudispinosus</u>			
MWT	5	1	41-	41	.9
MWT	6	2	36-	40	1.4
MWT	8	1	50-	50	1.3
MWT	9	1	59-	59	2.5
Total		5	36-	59	6.1
<u>Notoscopelus</u>					
		<u>resplendens</u>			
MWT	2	3	31-	35	1.6
MWT	3	1	28-	28	.3
MWT	4	3	27-	69	5.0
MWT	5	2	28-	38	1.0
MWT	6	6	26-	38	2.9
MWT	7	1	23-	23	.2
MWT	8	10	26-	68	8.0
MWT	9	6	26-	33	2.0
MWT	10	1	29-	29	.2
Total		33	23-	69	21.2
<u>Symbolophorus</u>					
		<u>veranyi</u>			
MWT	1	1	55-	55	2.0
Total		1	55-	55	2.0
<u>Taaningichthys</u>					
		<u>minimus</u>			
MWT	5	1	52-	52	1.7
Total		1	52-	52	1.7
<u>Cetomimiformes</u>					
<u>Cetomimoidei</u>					
<u>Rondeletiidae</u>					
<u>Rondeletia</u>					
		<u>loricata</u>			
MWT	9	1	77-	77	13.0
Total		1	77-	77	13.0
<u>Lophiiformes</u>					
<u>Lophioidei</u>					
<u>Lophiidae</u>					
<u>Lophius</u>					
		<u>americanus</u>			
MWT	7	1	33-	33	1.2
MWT	9	1	43-	43	2.8
Total		2	33-	43	4.0

Station	Quantity	Size (mm SL)		Volume (ml)
		min.	max.	
<u>Ceratioidei</u>				
<u>Ceratiidae</u>				
<u>Cryptopsarus</u>				
	<u>couesi</u>			
MWT	1	20-	20	.4
MWT	9	20-	20	.4
Total	2	20-	20	.8
<u>Beryciformes</u>				
<u>Stephanoberycoide</u>				
<u>Melamphaeidae</u>				
<u>Melamphaes</u>				
	<u>pumilus</u>			
MWT	7	22-	22	.2
MWT	8	22-	22	.2
Total	2	22-	22	.4
<u>Poromitra</u>				
	<u>capito</u>			
MWT	4	29-	29	.5
MWT	7	90-	90	16.0
MWT	9	34-	34	1.0
Total	3	29-	90	17.5
<u>Scopeloberyx</u>				
	<u>opisthopterus</u>			
MWT	1	31-	36	1.2
MWT	5	16-	16	.1
MWT	9	34-	34	.8
Total	4	16-	36	2.1
<u>Scopelogadus</u>				
	<u>beanii</u>			
MWT	1	107-	107	30.0
MWT	2	86-	86	14.5
MWT	5	108-	108	28.0
MWT	7	68-	114	100.0
MWT	8	111-	111	22.0
MWT	9	66-	81	17.0
Total	13	66-	114	211.5
<u>Scopelogadus</u>				
	<u>mizolepis</u>			
MWT	4	17-	17	.1
MWT	7	17-	17	.1
Total	2	17-	17	.2

Station	Quantity	Size (mm SL)		Volume (ml)
		min.	max.	
<u>Lampridiformes</u>				
<u>Trachipteroidei</u>				
<u>Regalecidae</u>				
<u>Regalecus</u>				
MWT 6	<u>glesne</u>			
	1	267-	267	2.4
Total	1	267-	267	2.4
<u>Gasterosteiformes</u>				
<u>Syngnathoidei</u>				
<u>Syngnathidae</u>				
<u>Hippocampus</u>				
MWT 1	<u>erectus</u>			
	1	59-	59	1.2
Total	1	59-	59	1.2
<u>Scorpaeniformes</u>				
<u>Scorpanenoidei</u>				
<u>Triglidae</u>				
<u>Peristedion</u>				
MWT 5	<u>miniaturum</u>			
	1	35-	35	.3
Total	1	35-	35	.3
<u>Perciformes</u>				
<u>Scombroidei</u>				
<u>Gempylidae</u>				
<u>Diplospinus</u>				
MWT 2	<u>multistriatus</u>			
	1	12-	12	.1
MWT 7	1	18-	18	.1
MWT 8	1	38-	38	.1
Total	3	12-	38	.3
<u>Trichiuridae</u>				
<u>Benthodesmus</u>				
MWT 7	<u>elongatus</u>			
	1	726-	726	90.0
Total	1	726-	726	90.0
<u>Stromateoidei</u>				
<u>Nomeidae</u>				
<u>Nomeus</u>				
MWT 1	<u>gronovii</u>			
	1	43-	43	1.2
Total	1	43-	43	1.2